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To Mr. K. Demal
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Attn: Mr. V.D. Horsley

TRAFALGAR TS - SURFACE DRAINAGE STUDY

C.B.H. Cragg and R. Tsang

The access road and switchyard of Trafalgar TS experiences severe flooding during the spring of each year. A review of the station drainage found that ditches, in the area of flooding, and outlet culverts were undersized for the 25 year storm flow. Snow accumulation in the ditches and over the culverts restricts release of spring melt water. This report contains a list of remedial works to improve station drainage.

INTRODUCTION

At the request of Transmission Environment, who were acting for Central Region, a review of surface drainage was performed for Trafalgar TS. Inspection reports, including photographs, of spring flooding, provided by Transmission Environment and by Civil Works, were major inputs to this review as Civil Research did not become involved in this work until late April, 1986.

Trafalgar TS is located in relatively flat lying topography in the path of a former natural drainage channel. Natural drainage enters the station lands from the northwest, is conveyed around the switchyard area by perimeter ditches, and rejoins its former course at the southeast corner of the property (see Figure 1). In winter, snow fills these ditches and completely covers the 0.6 m diameter culverts which are intended to convey runoff water under the railway and road embankments on the south and east sides of the property. To date, snow fencing has not been effective in preventing this occurrence. Meltwater, possibly combined with rain in late winter, has been reported to flood the access road under 1 to 2 feet of water. This flooding occurs where the access road forms an S bend just north of the main entrance gate to the station.

job	file	date	report no.
740643-194-40131	843.11	August 14, 1986	86-188-K

The purpose of this study was to determine the causes of the observed flooding and to propose remedial construction to alleviate the problem. Drawings and cost estimates for the proposed construction were requested. Estimating was performed by the Construction and Services Group, Pickering GS.

INVESTIGATION METHODS

The scope of the problem was established by inspecting the site and examining the inspection reports of Transmission Environment and Civil Works. A tape and level survey of the existing ditches was performed to establish the "as constructed" ditch grades and cross sections. Transmission Environment supplied a runoff inflow to the site for the 25 year storm. The capacity of the existing ditches to carry runoff was calculated for various cross-sections and compared to the storm inflow. The best positioning of snow fences was also investigated.

STUDY RESULTS

The existing grades of the access road and the ditches surrounding the TS are shown in the following figures:

Figure 2 - Access Road and North Ditch
Figure 3 - West Ditch and South Ditch

It may be seen from these figures that flooding of the access road occurs where the west ditch is the shallowest and has very little gradient. In comparison to the 25 year storm inflow volume of 70.3 ft^3/sec/1/, the ditch near the S bend in the road can only carry about 9 ft^3/sec/2/. Volume of runoff during spring melt may greatly exceed the 25 year storm quantity/1/.

The design cross section of the ditches, shown in Figure 4, has two slope angles for the sides of the ditch. It is believed that the lower one foot of the ditch was intended to carry all the runoff because the cross sectional area of this portion of the ditch is about the same as that for the two foot diameter outlet culverts (under the south road and under the railway embankment). In other words, the culverts as well as critical portions of the ditches are undersized to carry the calculated 25 year storm flood. Calculations indicate that a 2-1/2 foot deep ditch with a 0.5% slope would be required to carry this flood. A five foot diameter culvert is needed to provide a flow cross section compatible with the 2-1/2 foot deep ditch.

In order to alleviate the spring flooding problem, measures should be implemented to increase the capacity of the drainage works (ditches and culverts) and to reduce the capacity reductions caused by snow drifts in the ditches and over the culvert entrances. Due to restrictions in available grade, the only practical approach to deepening the access road ditch is to raise the road about 2 feet. Details of this improvement are given in Figures 2 and 4. This improvement will force the bulk of the runoff to flow through the ditch route on the west and south of the TS.

Minor regrading of the west ditch and replacement of the south road culvert are required to complete this improvement. Details of this work are shown in Figures 3 and 5.

Snow fencing causes an accumulation of snow downwind of the fence for a distance equal to 15 times the fence height/3/ as shown in Figure 6. For the standard four foot fencing to be effective in protecting the west ditch, it should be located more than 60 feet upwind of the ditch. It has been located closer in recent years, causing snow to accumulate in the ditch. Some regrading of the upwind area (shown in Figure 7) may be required to supplement the snow protection of this ditch but simply relocating the fence should be tried first.

Water exiting the station's subsurface drainage system joins the surface runoff from the west and south ditches at the southeast corner of the TS. This ditch is clogged with sediment which extends into the underground pipes under the TS. This ditch should be cleaned out and the subsurface pipes flushed to allow runoff water to escape freely down the natural drainage area (see Figure 8).

At the end of the wetland farthest from the TS, a gravel access road along the gas pipelines is acting as a barrier to the surface runoff. A steel pipe installed under this road has inadequate capacity to remove storm runoff. This barrier may be contributing to the siltation occurring in the upstream ditch and wetland. Building a ford in this road (as shown in Figure 9) is recommended to complete the runoff channel improvements.

The ditch to the north of the switchyard has reasonable grade but is shallow. Regrading of this ditch, as shown in Figure 2, is recommended. As with the west and south ditches, the culvert under the railway embankment is small compared with the ditch capacity. Figure 10 shows suggested improvements to this culvert. However, the improvements to the road and west ditch may reduce runoff in this area of the TS rendering improvements to this culvert unnecessary. This construction has been priced but should not be initiated until the need for it is established by one or two years operation with only the road and west ditch improved. The railway culvert design/4/ should be checked by a railway engineer to ensure it meets railway specifications.

COST ESTIMATES

Prices received from the Construction Services Group for this work are summarized below and on Table I.

A) Essential West Ditch Improvements

a)	raise access road approximately 2 ft	$ 86,928
b)	temporary access road to bypass above work area	7,000
c)	regrade west ditch	4,449

d)	replace south culvert	19,904	
e)	rip rap inflow to west ditch	4,023	
	SUB TOTAL	$121,504	(includes $22,145 contingency)

B) Desirable Off Site Improvements

f)	flush pipe arch & clean ditch	14,045	
g)	build ford in gas pipeline road	12,838	
	SUB TOTAL	$ 26,883	(includes $5,377 contingency)

C) Deferrable Improvements

h)	regrade north ditch	$ 3,937	
i)	build west snow fence berm	32,679	
j)	replace railway culvert	33,204	
	SUB TOTAL	$ 69,820	(includes $13,691 contingency)

These items, (a) to (j), have been priced individually. By contracting several items in one package a reduction in cost on the order of 10 to 20% may be realized. If the TS staff choose to forgo direct access to the transmission line, the cost of improving the south road culvert is reduced to a removal cost of $7,000. Prices for the railway culvert and gas pipeline work may vary as external contractors should be enlisted to perform these jobs.

It is recommended that all items listed under (A) above be undertaken this year plus item (h). Items listed under (B) should also be done but may be deferred until next year, if funding is not available to do them this year. Items (i) and (j) should not be done until conditions at the TS, after the other improvements are made, prove these measures are necessary.

SUMMARY

Flooding at Trafalgar TS results from inadequate ditch capacity and clogging of the drainage system with snow. Recommendations and designs for improving the site drainage facilities have been provided along with an

estimate of cost for the work. A suggested sequence and priority for the work items has also been provided.

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CBHC/RT:LM

REFERENCES

1. Private conversation with Mr. V.D. Horsley, Transmission Environment.

2. Streeter, V.L. "Fluid Mechanics". (Chapter 11 - Open Channel Flow), 751 p, McGraw-Hill, 1977.

3. Private conversation with Mr. J. Gruspier, Head Earth and Environmental Research, Ministry of Transportation and Communications

4. "Handbook of Steel Drainage and Highway Construction Products". 347 p, American Iron & Steel Institute, New York, 1971.

TABLE I

10 June 1986

	Access Road	Raise Approach Road	Regrade Ditch	Replace Culvert	Flush Out Pipe Arch.	Inter. Prov. Pipe	Regrade Ditch	Provision of Berm	Replace Culvert	Place Rip-Rap West Ditch	
Directs	3800	44690	2486	10675	7221	6600	2200	16800	17070	2200	113,742
Construction Indirects	1140	13407	746	3203	2166	1980	660	5040	5121	660	34,123
Construction O.H.	973	11445	637	2734	1849	1690	563	4303	4372	563	29,129
Contingency	1087	17386	580	2492	2809	2568	514	6536	6641	600	41,213
	7000	86928	4449	19104	14045	12838	3937	32679	33204	4023	218,207

86-188

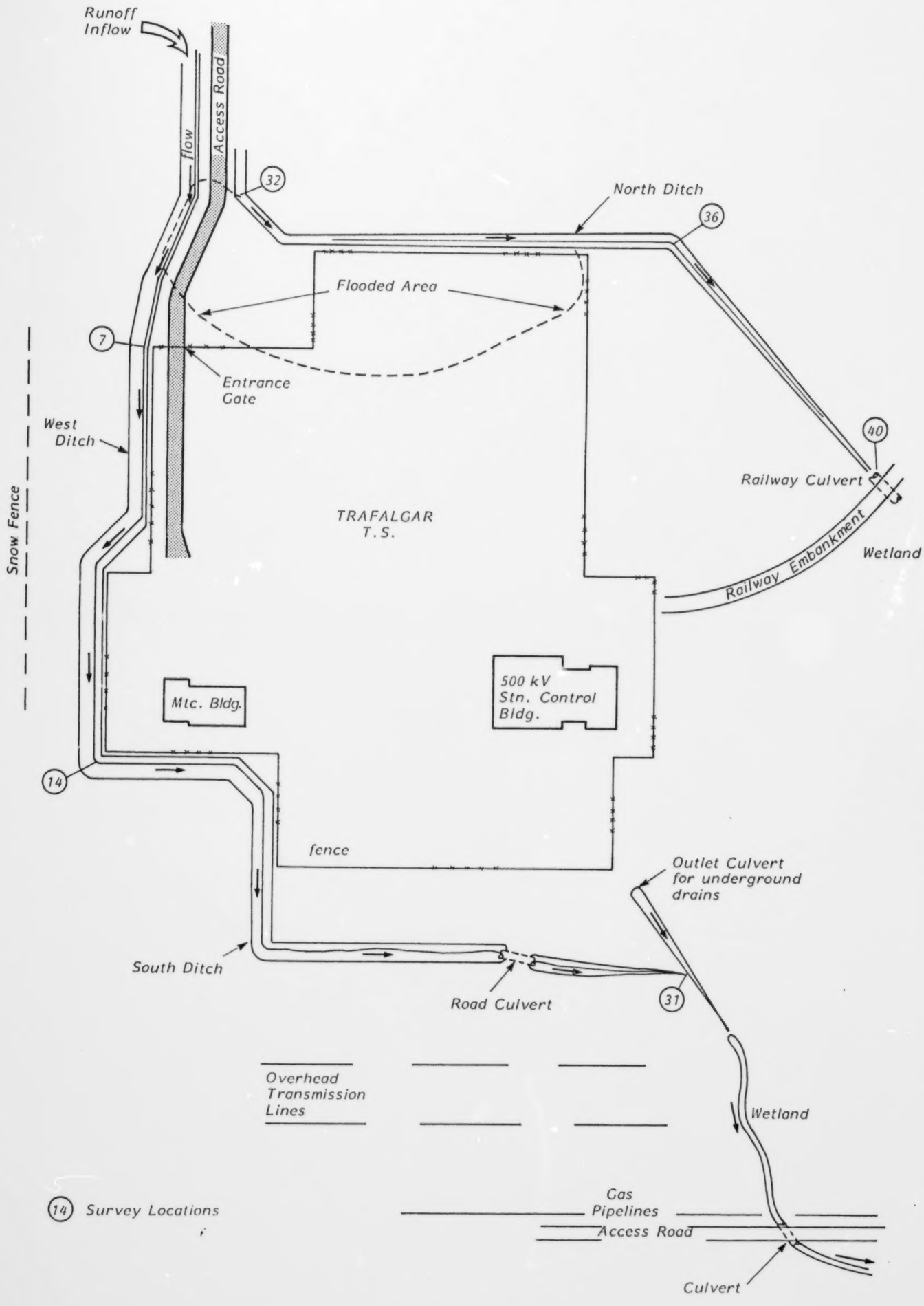
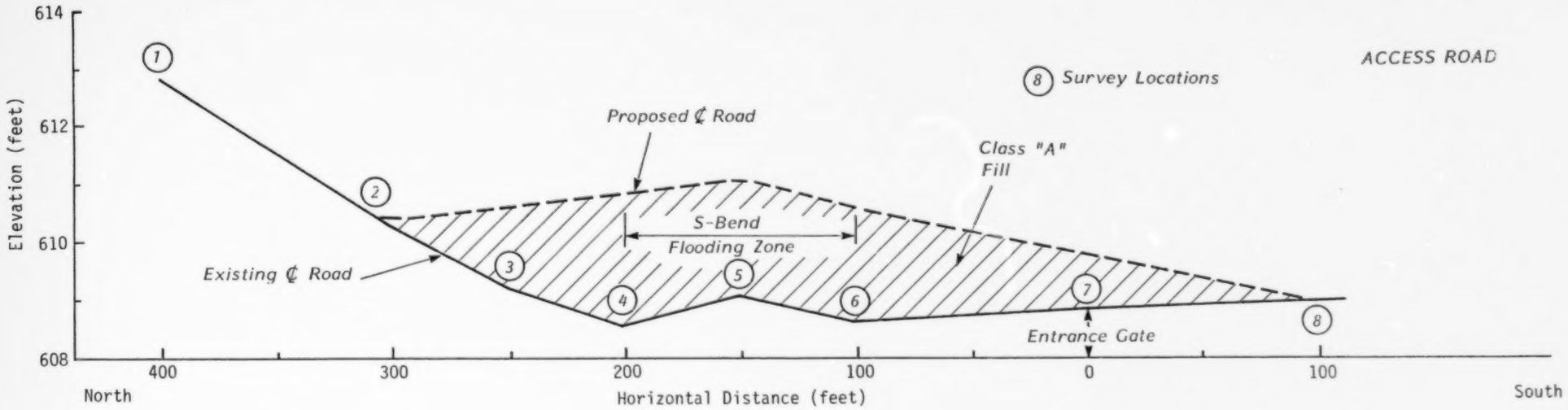


FIGURE 1
TRAFALGAR T.S. DRAINAGE PLAN

86-188
200556 RD



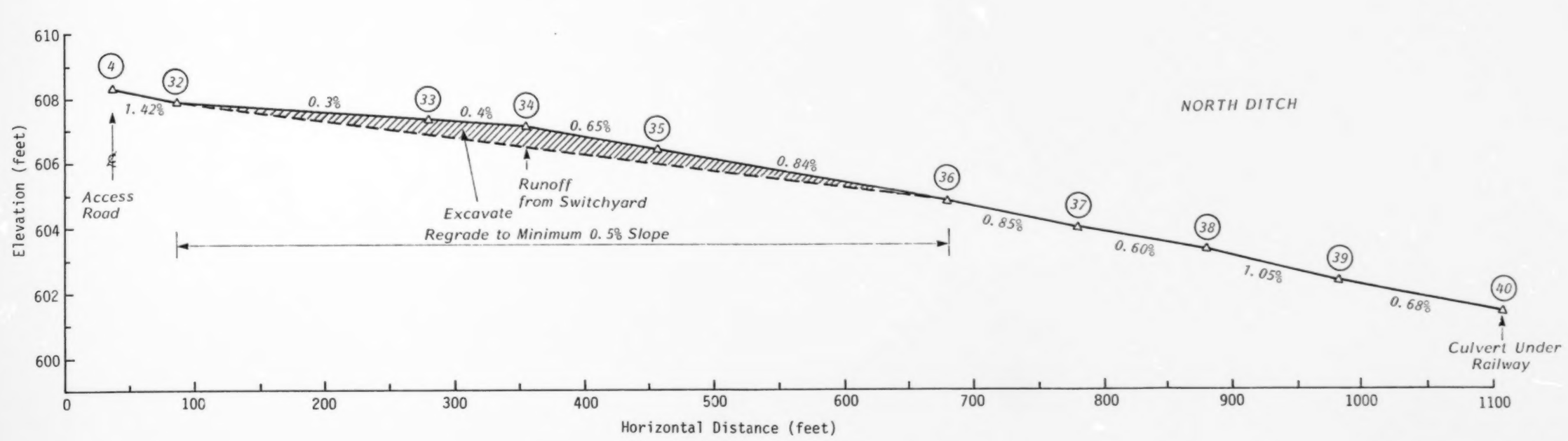
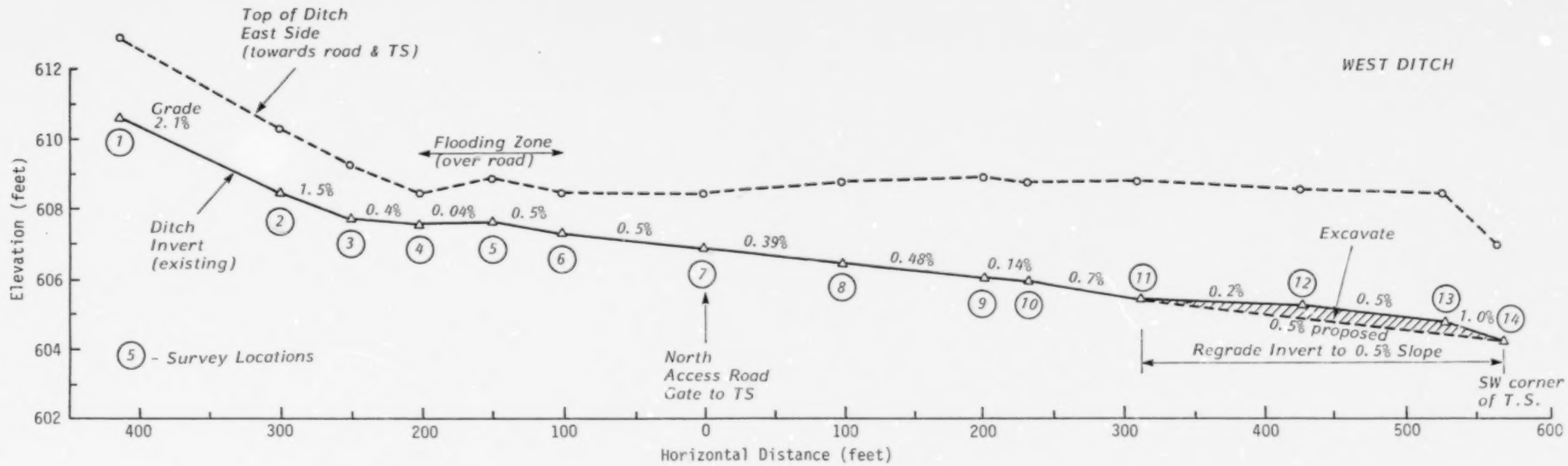


FIGURE 2

SECTIONS OF ACCESS ROAD & NORTH DITCH
TRAFALGAR T.S.



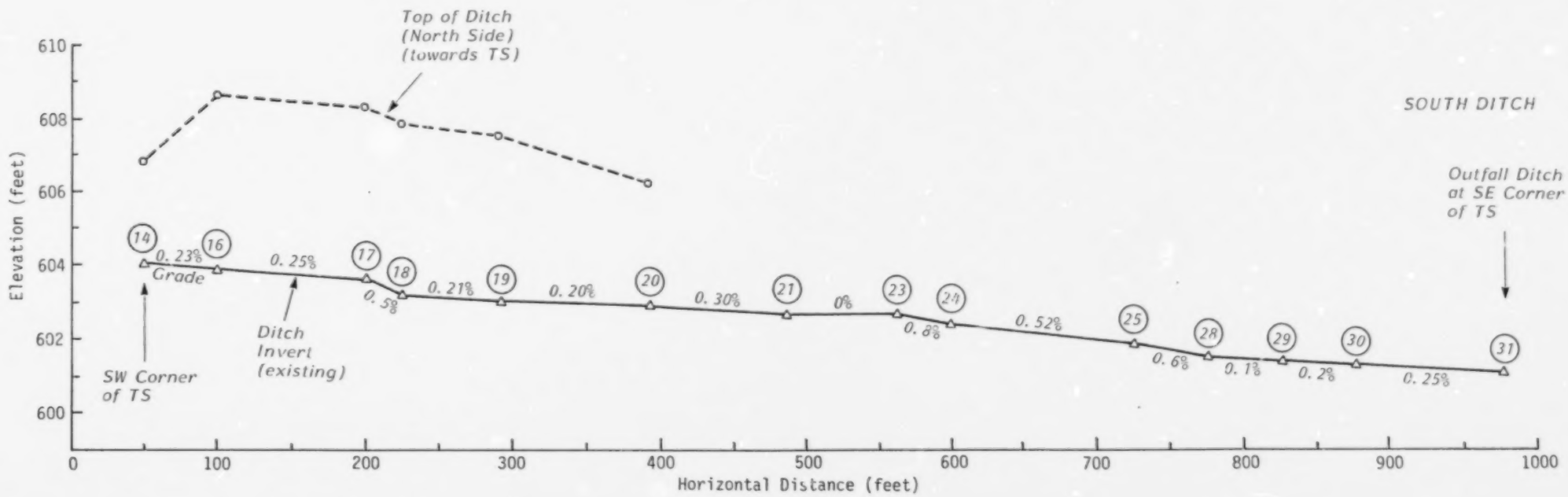
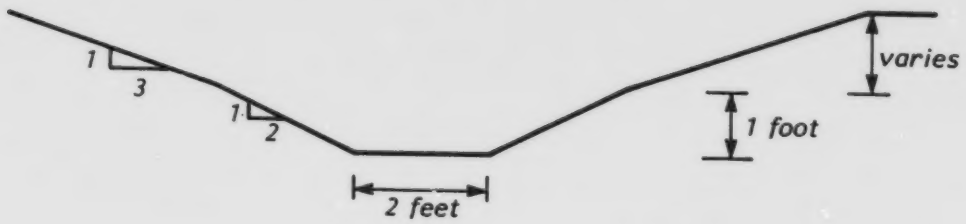


FIGURE 3

SECTIONS OF WEST & SOUTH DITCH
TRAFALGAR T.S.

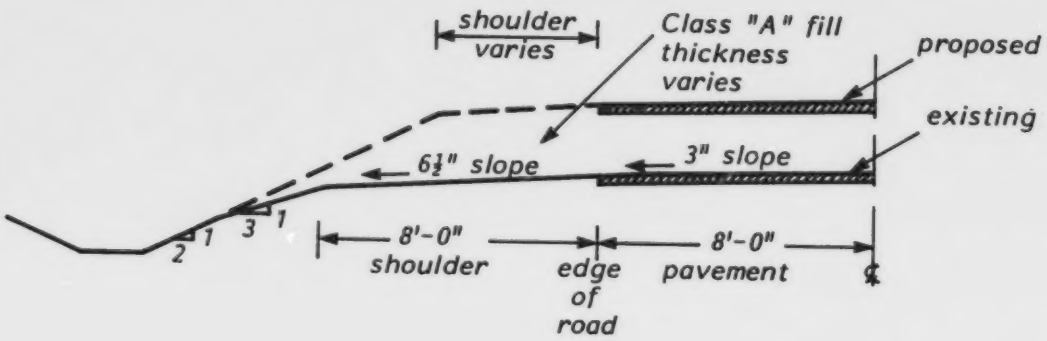
86-188

200558 RD



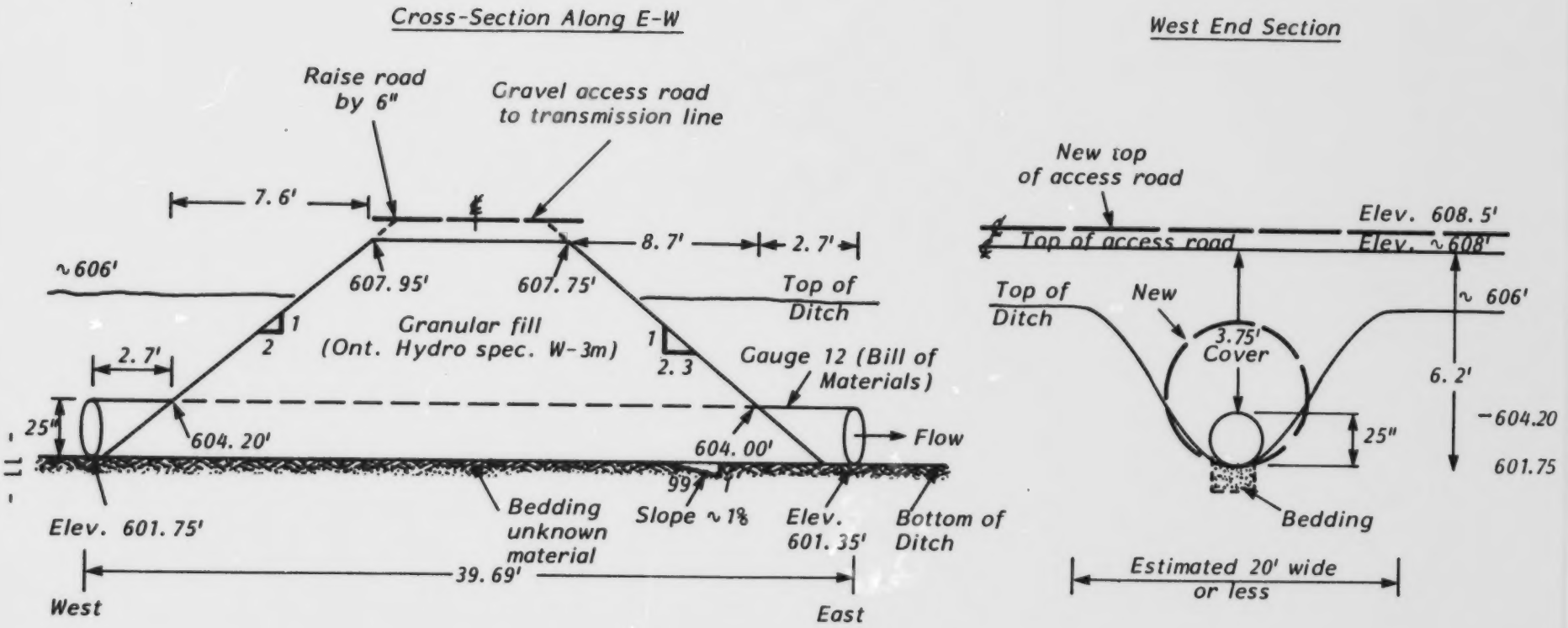
Typical Ditch Cross Section

Notes 1) Remove existing asphalt
2) Place class "A" fill in 6" lifts and compact to 98% std. proctor



Typical Existing and Proposed Access Road Cross Sections

FIGURE 4
DITCH AND ROAD SECTIONS



Not to scale - as dimensioned in feet

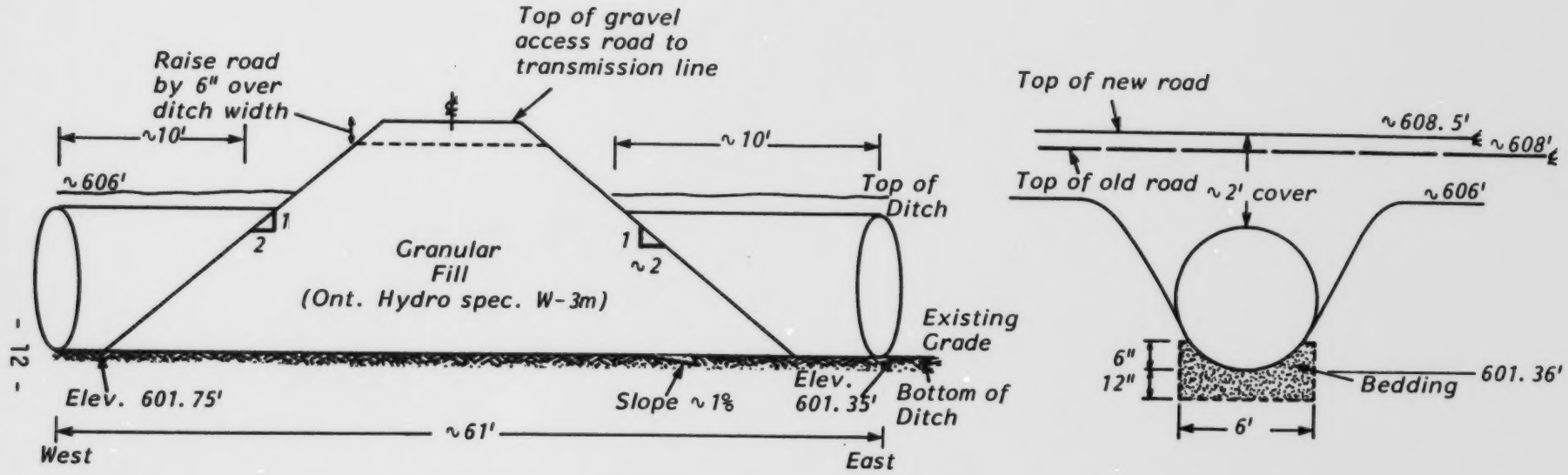
Recommendations: 1) If south access road not required remove 25"Φ culvert

2) Replace 25" Dia. existing culvert with 60" Dia. culvert such that access road has an elevation of 608.5'

FIGURE 5a

EXISTING CULVERT ON SOUTHSIDE OF T.S. UNDER ACCESS ROAD

171741 RD
86-188



Not to scale - as dimensioned in feet

Recommendations: (1) Remove old culvert (25" Φ) and leave a ditch only if access road not required

(2) New culvert H20 60" Dia. Gauge 8, 3"x1" corrugations by 61' long galvanized steel with granular fill bedding compacted to 98% of the standard Proctor maximum dry density in 6" layers.

FIGURE 5b

NEW CULVERT ON SOUTHSIDE OF T.S. UNDER ACCESS ROAD

86-188
171742 RD

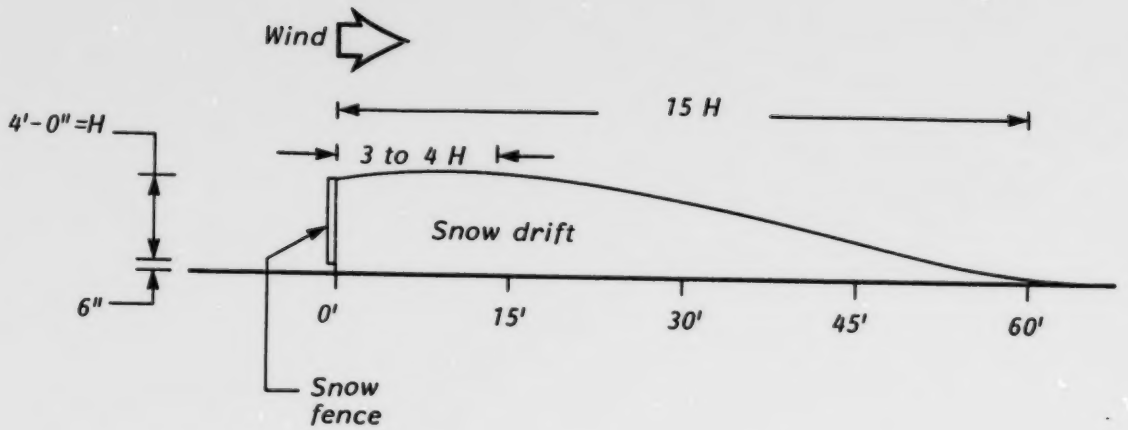


FIGURE 6

SNOW ACCUMULATION NEAR A SNOW FENCE

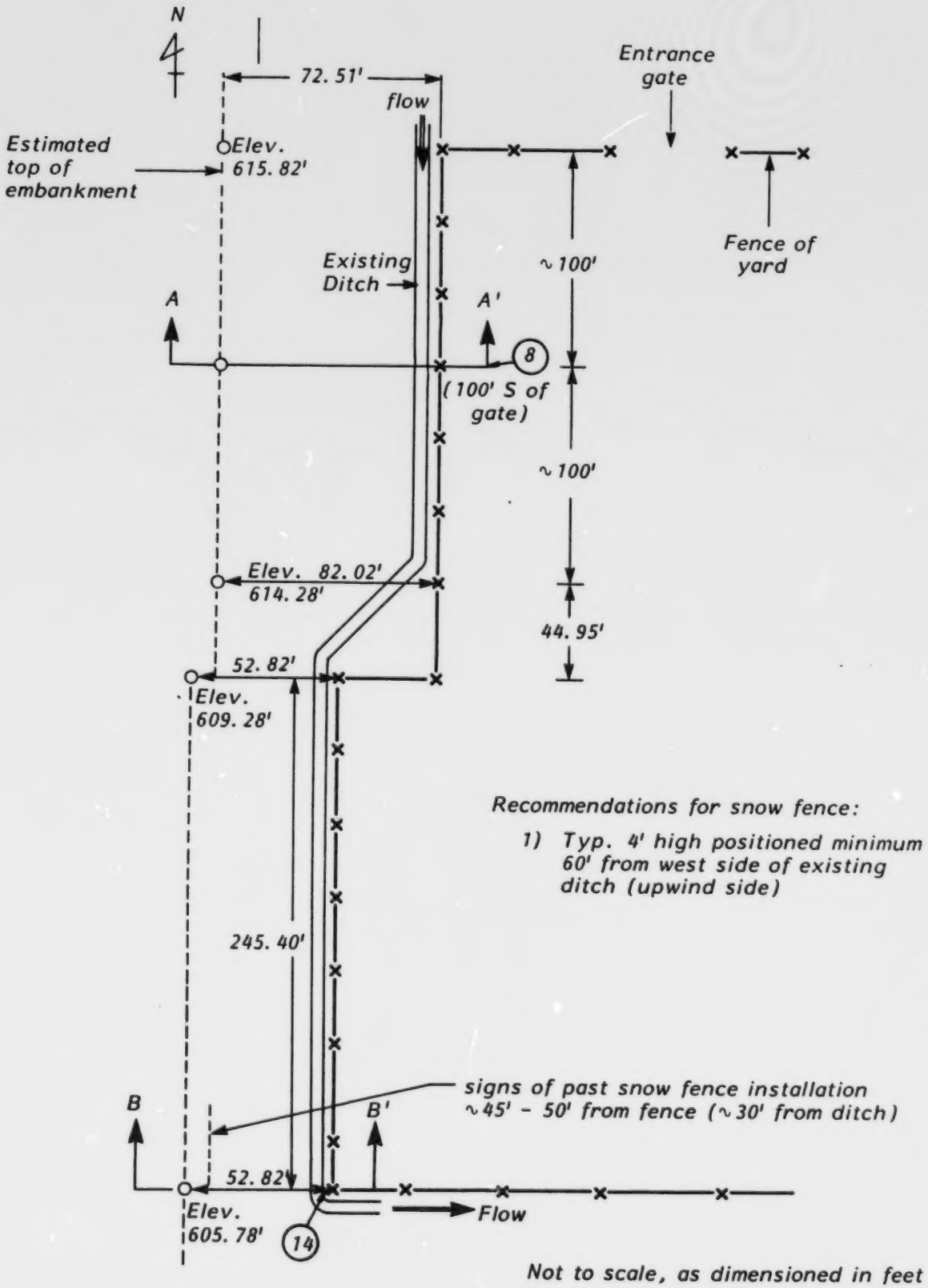


FIGURE 7a

WEST EMBANKMENT OF TS
FOR SNOW FENCING

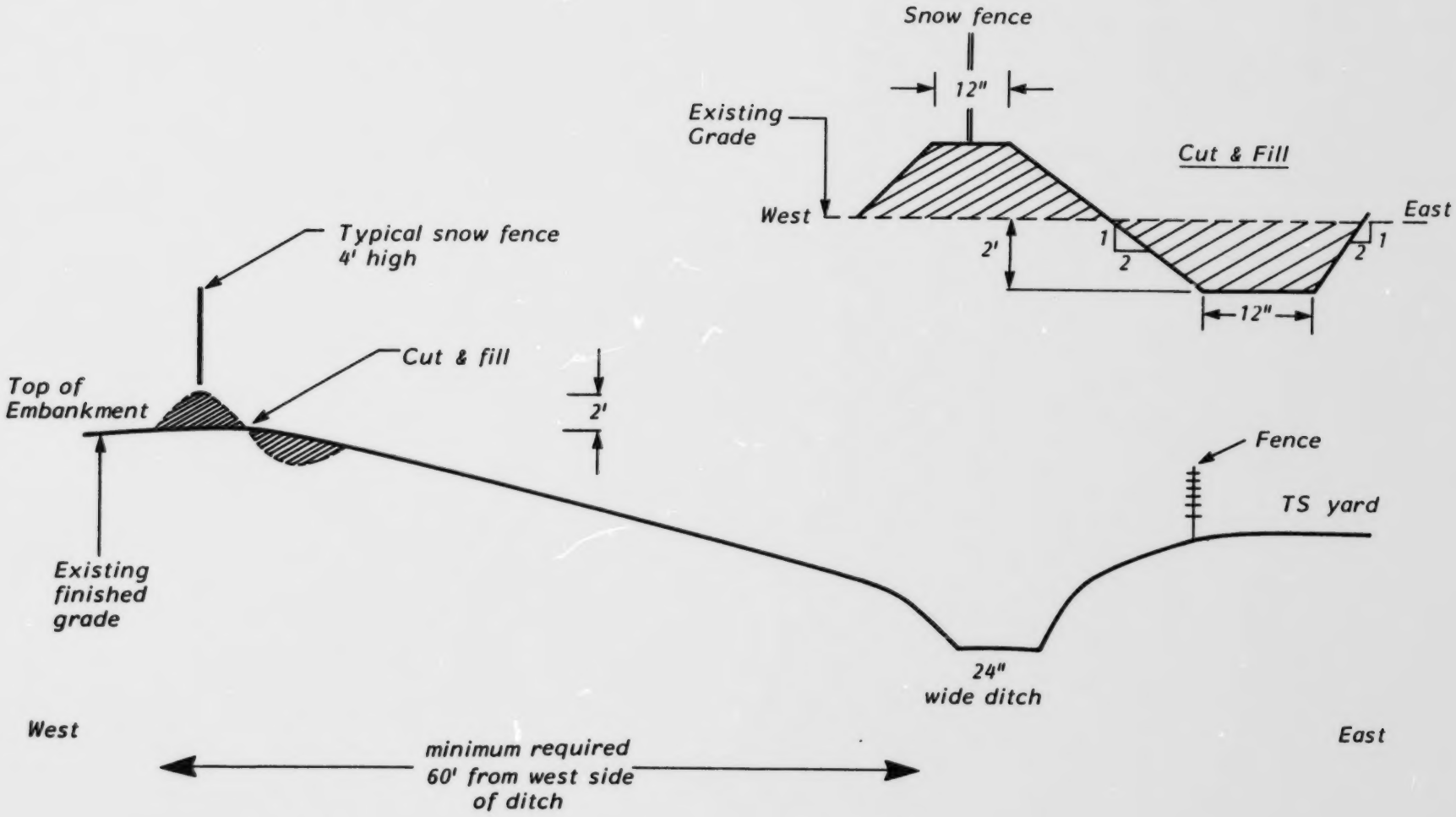
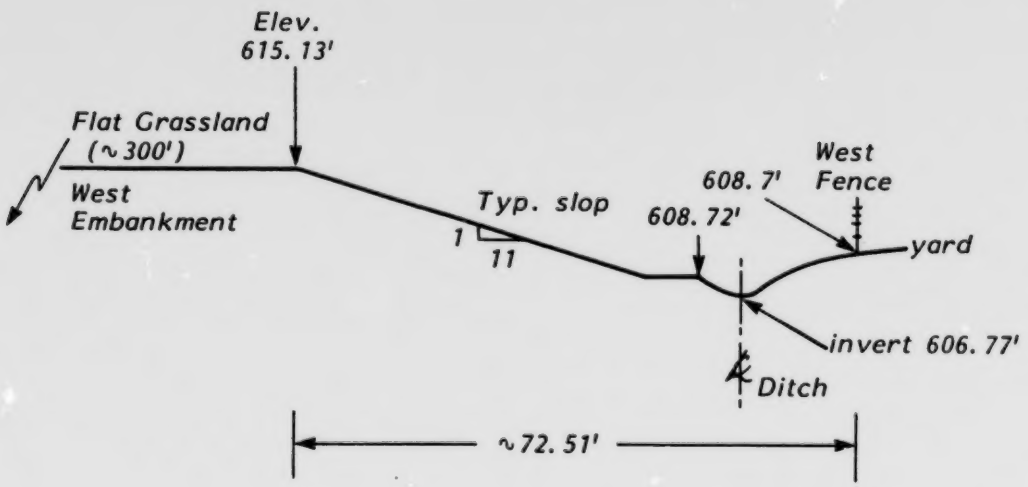


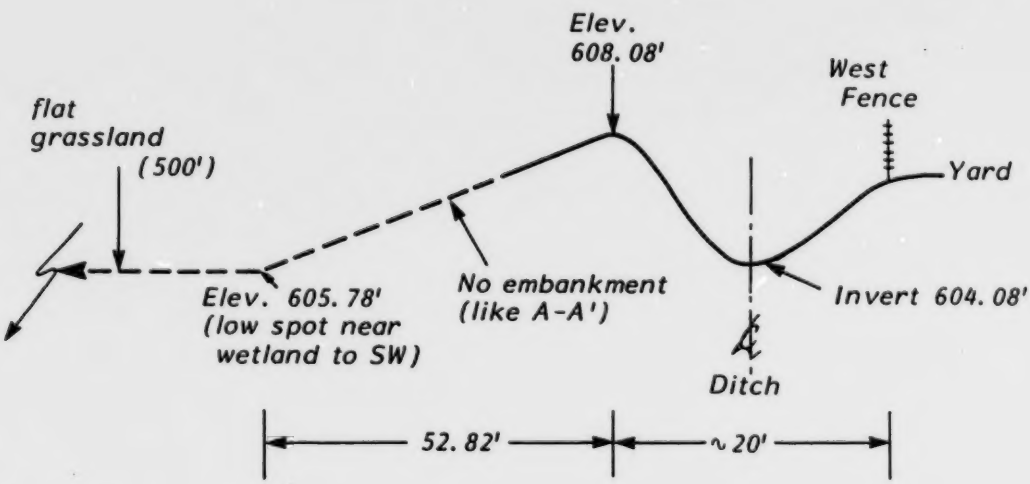
FIGURE 7b

TYPICAL CROSS-SECTION FOR SNOW FENCING

Section A-A'



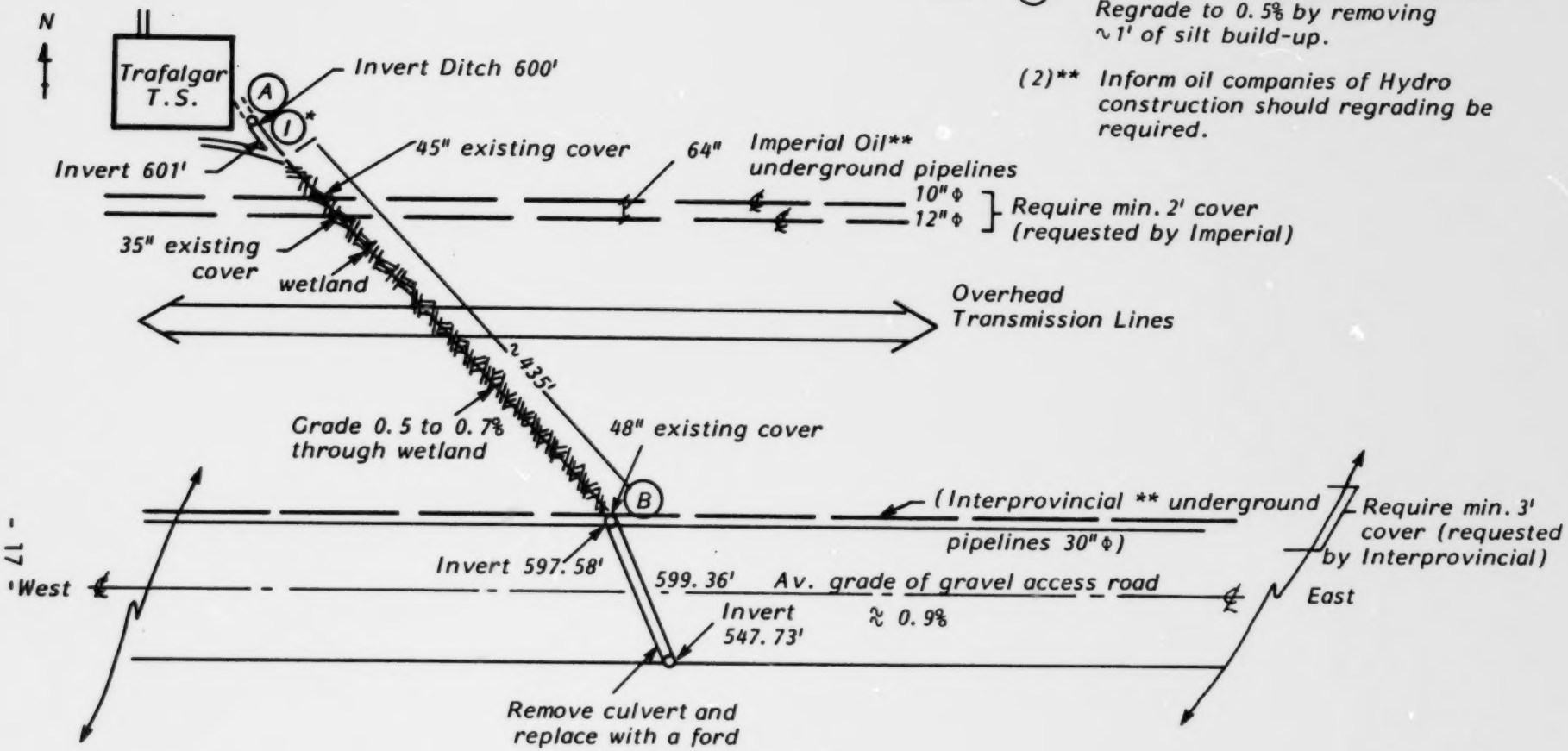
Section B-B'



Not to scale - as dimensioned

FIGURE 7c

WEST EMBANKMENT OF T.S. FOR SNOW FENCING



Recommendations:
1) Clean out ditch (1)* from T.S. drainage system with 0.5% grade and remove silt build-up (~1 foot near T.S. until level with natural grade of wetlands (Section A-B)
2) Remove culvert under gravel access road and replace with a ford (details to follow)

FIGURE 8a

OFF-SITE DETAILS - SOUTHEAST OF T.S.

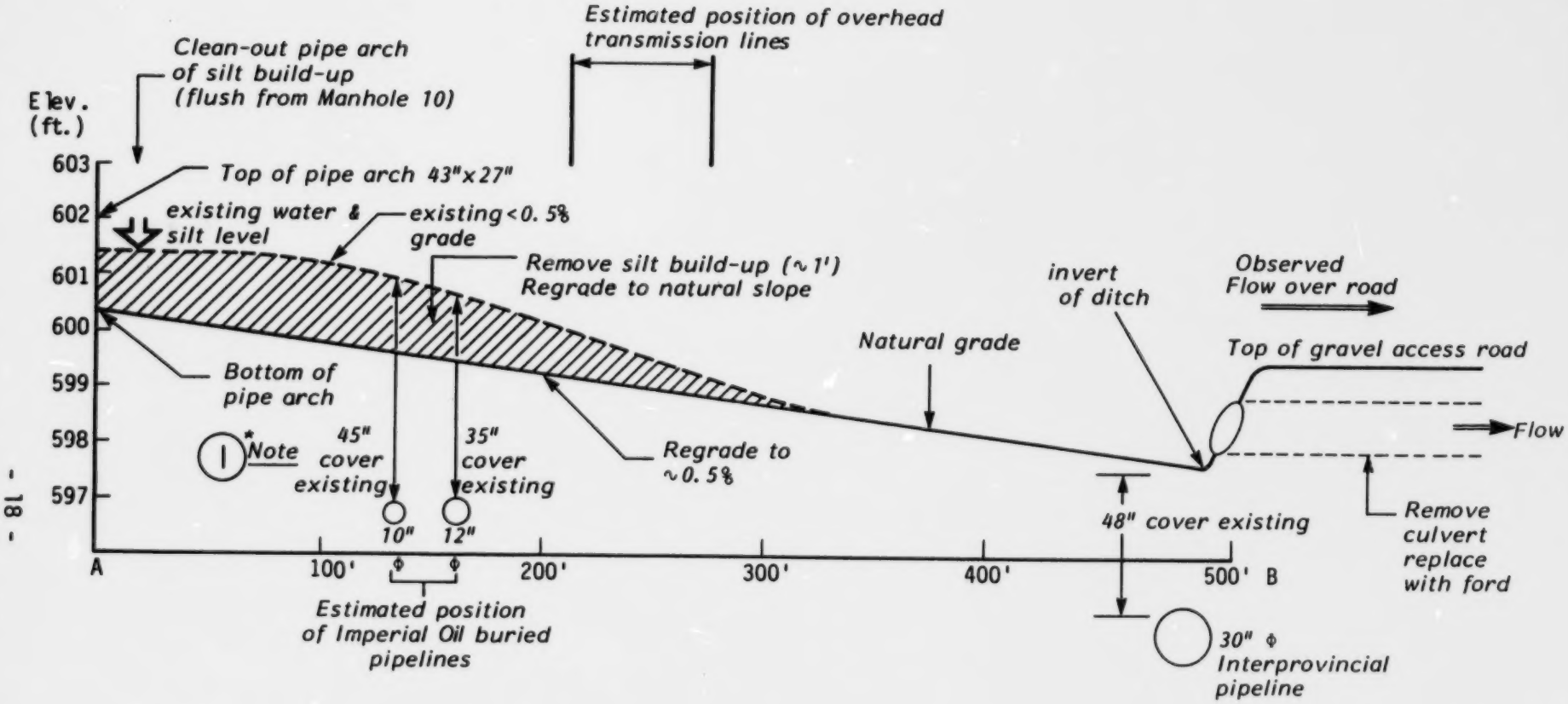


FIGURE 8b

OFF-SITE DETAILS - SOUTHEAST OF T.S.

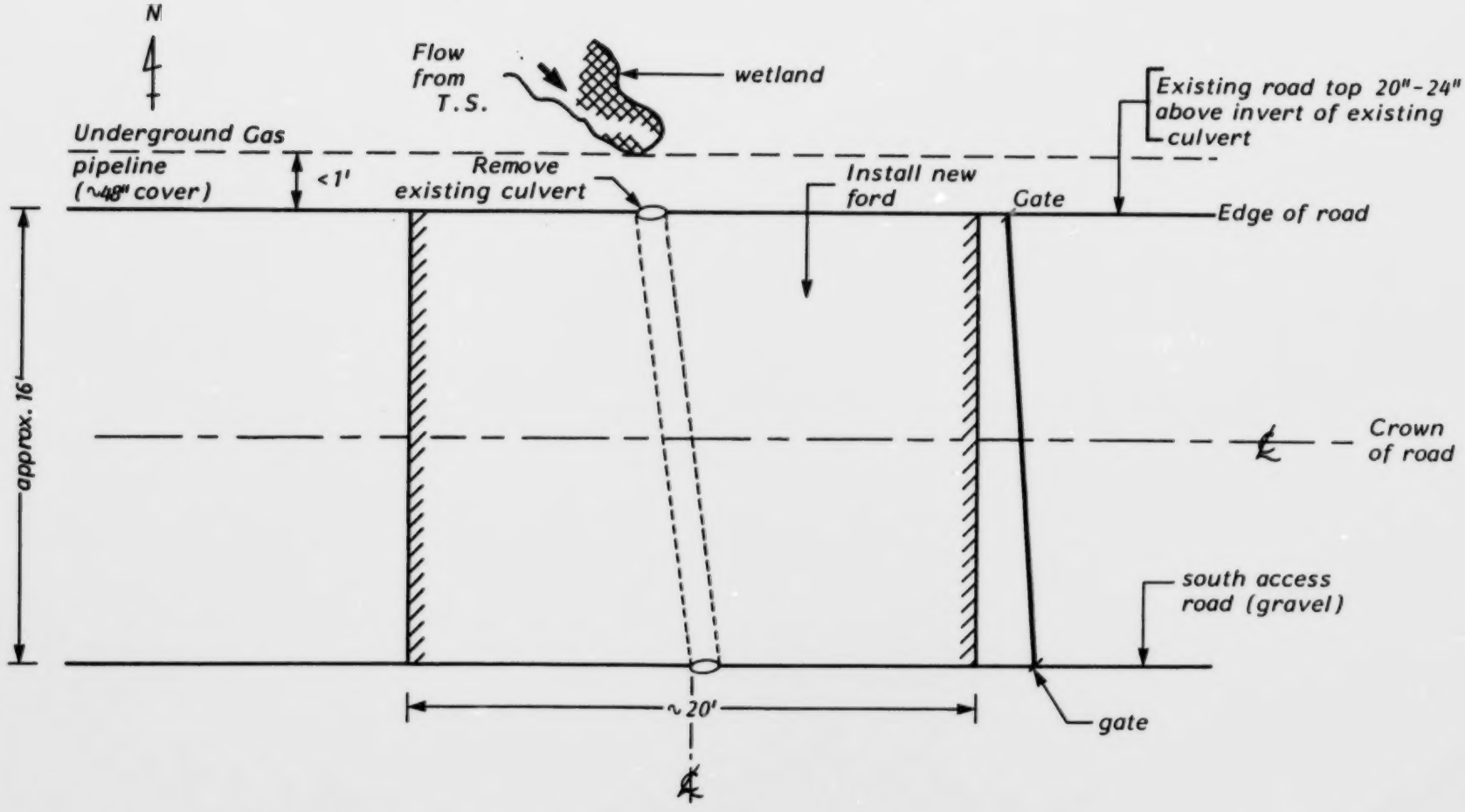


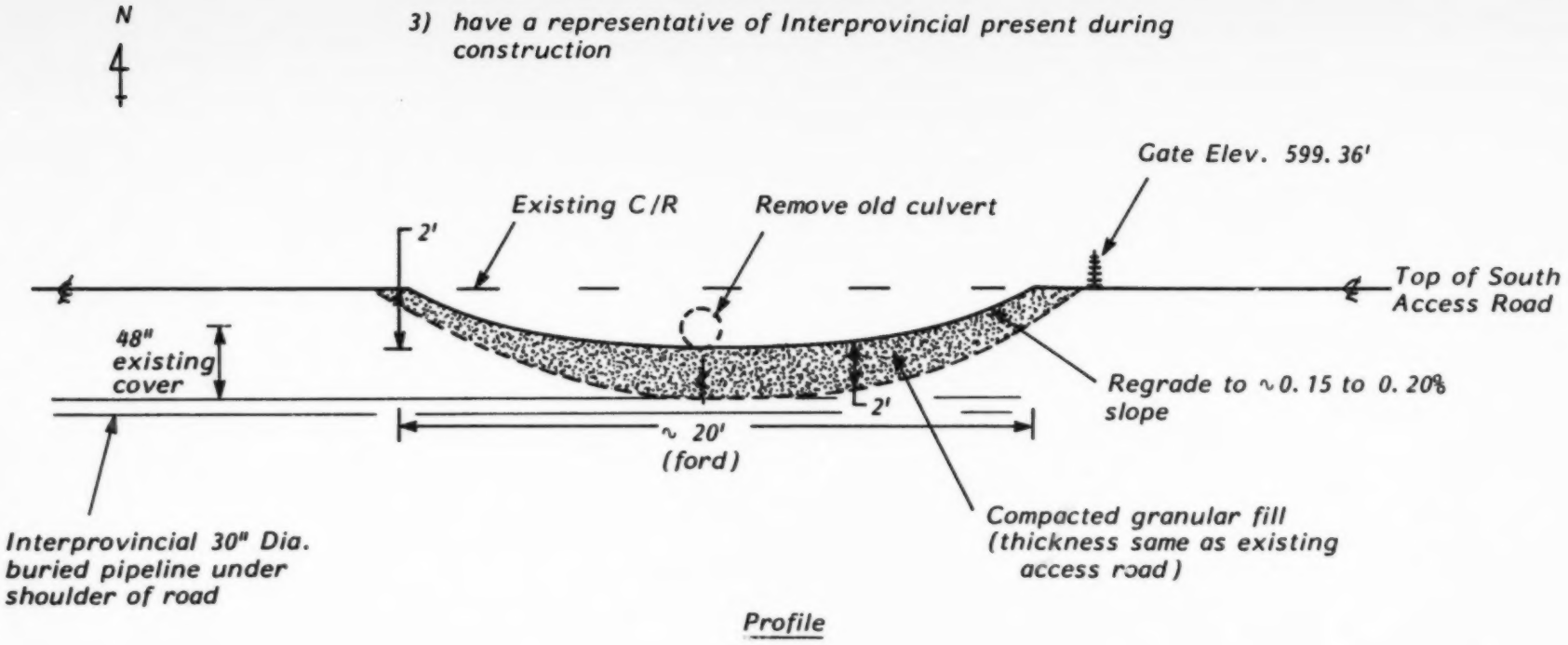
FIGURE 9a

DETAILS OF FORD FOR SOUTH ACCESS ROAD

Note: 1) C/R, crown of road

2) check cover that ford will provide over buried gas pipeline during construction and obtain Interprovincial's approval if less than 3 ft will be provided

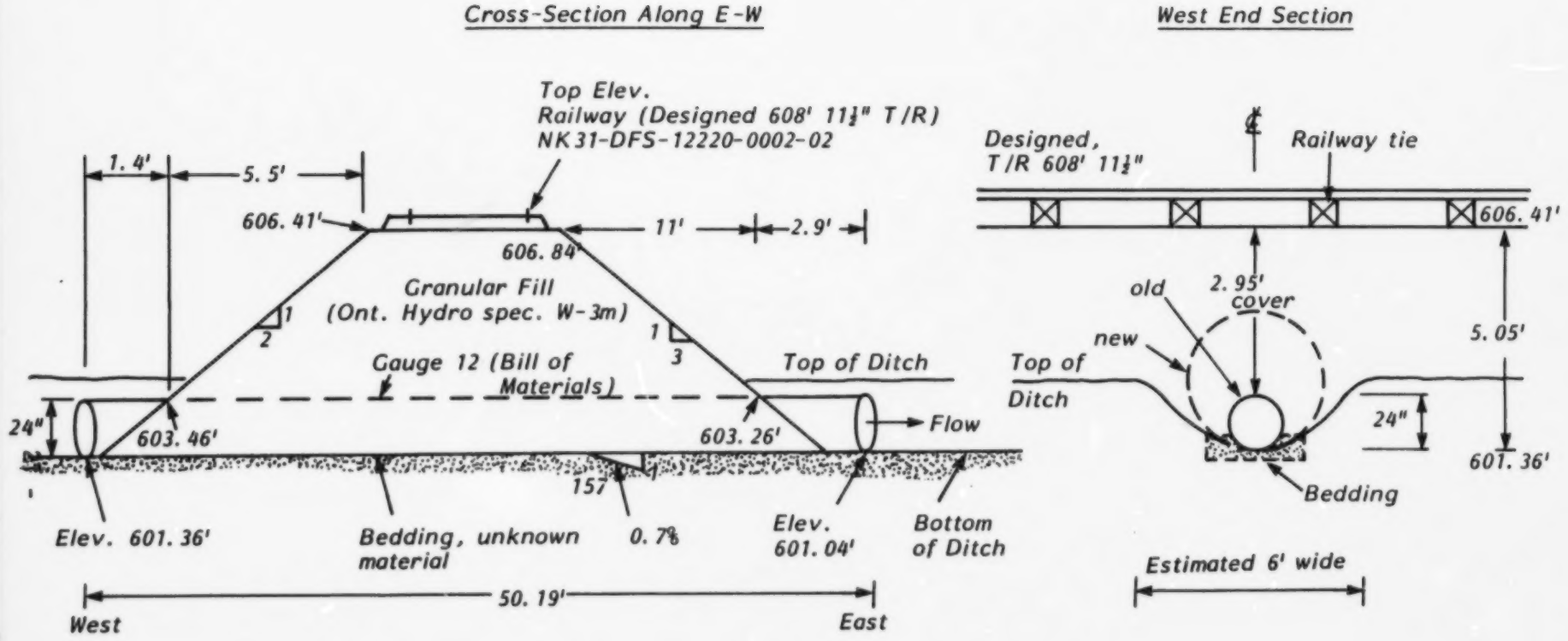
3) have a representative of Interprovincial present during construction



Profile

FIGURE 9b

DETAILS OF FORD FOR SOUTH ACCESS ROAD



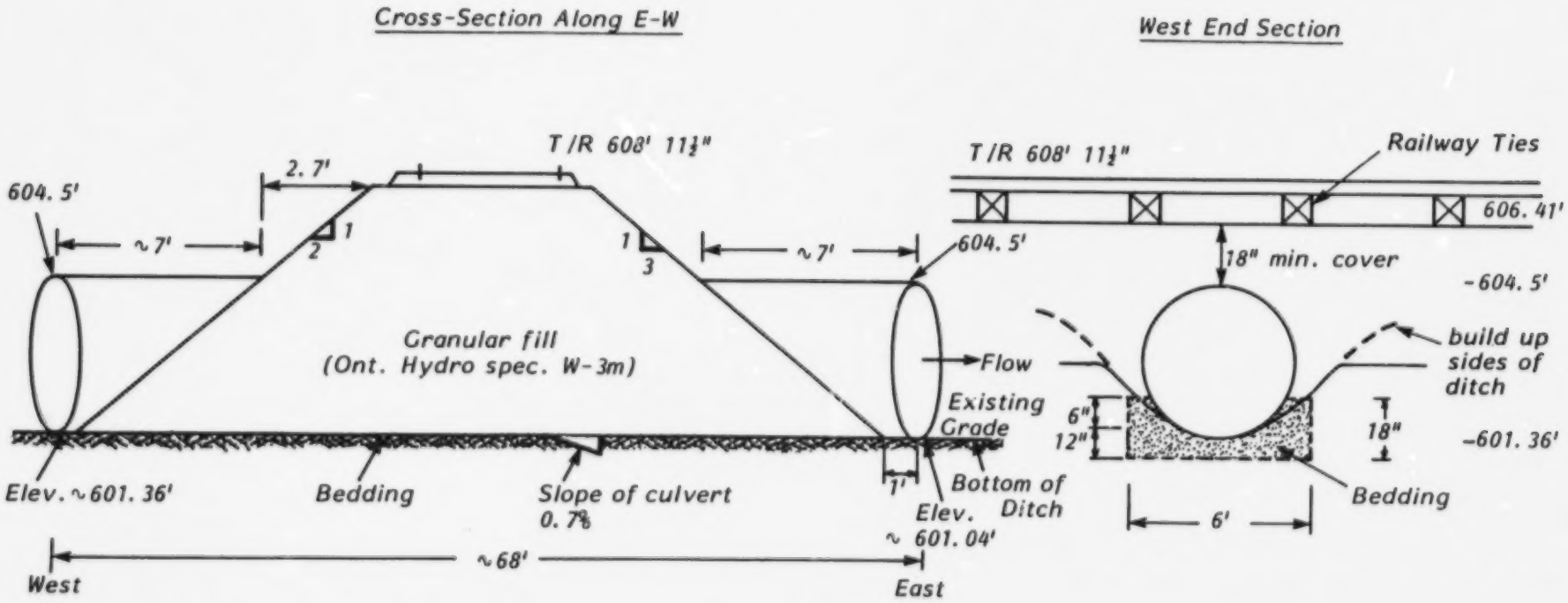
Not to scale - as dimensioned in feet

Recommendation: 1) *Replace 2' Dia. existing culvert with 42" dia. culvert such that railway line is the same as before.*

FIGURE 10a

EXISTING CULVERT BY RAILWAY

86-18871751 RD



Not to scale - as dimensioned in feet

T/R - Top of Railway Elevation

Recommendations: 1) New culvert E80 42" Dia., Gauge 8, 3"x1" corrugations by 68' long galvanized steel with granular fill bedding compacted to 98% of the Standard Proctor of maximum dry density in 6" layers.

FIGURE 10b

NEW CULVERT BY RAILWAY

APPENDIX "A"

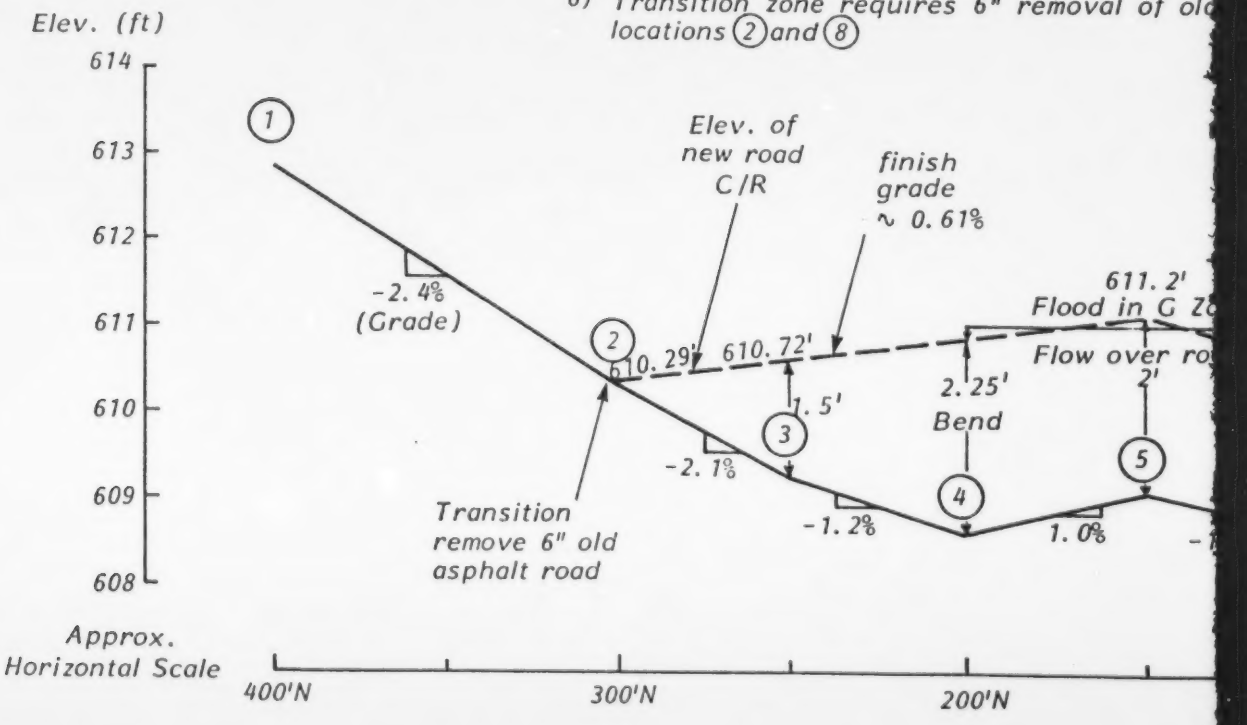
LIST OF FIGURES FOR APPENDIX "A"

Figure Number	Title
1	Longitudinal Section of North Access Road Along Crown of Road
2 to 6	Cross-Sections of North Access Road
7	Cross-Section of Silt-Filled Culvert at Southeast Corner of TS
8 to 16	Cross-Section of Ditches at Various Survey Locations

Recommendations:

1) Raise road in flooded section (i.e. (2) to
of existing road (see plan NK31-DFS-122
and NK31-DDS-12210-0003-03 for section S
2) Raise gate entrance (∿ 11") to new level o
3) Maintain bends at (4) and (6) with radius
4) Use granular "A" compacted to 98% of the
in 150 mm (maximum) thick layers (Ont.
5) Use granular "A" to raise road level up to
grade elev. = [finish grade elev. - roa
[(given below) thi
6) Transition zone requires 6" removal of old
locations (2) and (8)

N



LONGITUDINAL SECTI
(ALO

)to (8))(∿ 1 - 2 ft increase) along existing center-line
-12200-0001-RO, NK31-DFS-12220-0002-02,
ion S4, (omit railway details) and S6)

vel of road

dius of curvature of ∼100' (see NK31-DFS-1200-0001-03)

the standard proctor maximum dry density
nt. Hydro specs. W-3m)

up to required rough grade (where rough
road asphalt cover
thickness required

of old asphalt road for paving at survey

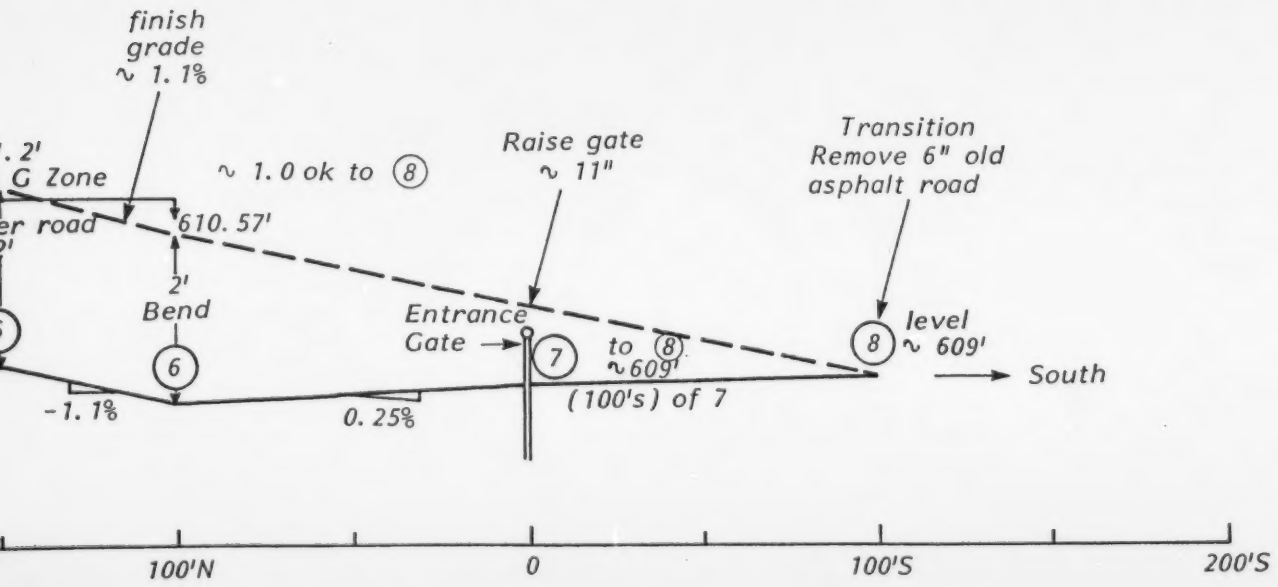


FIGURE 1

ECTION OF NORTH ACCESS ROAD (EXISTING)
ALONG CROWN OF ROAD ℄)

86-188

200559 RD

Detailed section at (3) (250' N of gate entrance)

NOTE: (Applicable to Survey Locations (2) to (8))

1) For Section 2 to 3 raise road level until level with elev. 610.29' @ (2) (300' N of gate entrance)
2) Refer to Fig. (1) for further details
3) Need to do detailed survey for the portion of road ((2) to (8)) with respect to ℄ ditch, road, entrance gate and possibly train tracks with proper control points stakes for the site
* 4) No "typical" sections are possible for the site - Need to survey existing site du variations from original design plans (Dwgs. No. NK31) for Sections (2) to (8)
5) Proposed new road (Sections (2) to (8)) may be altered depending on results of a detailed survey.

C/R - Crown of road finished elevation (ft)

E/R - Edge of road finished elevation (ft)

0 1 2
Scale in feet

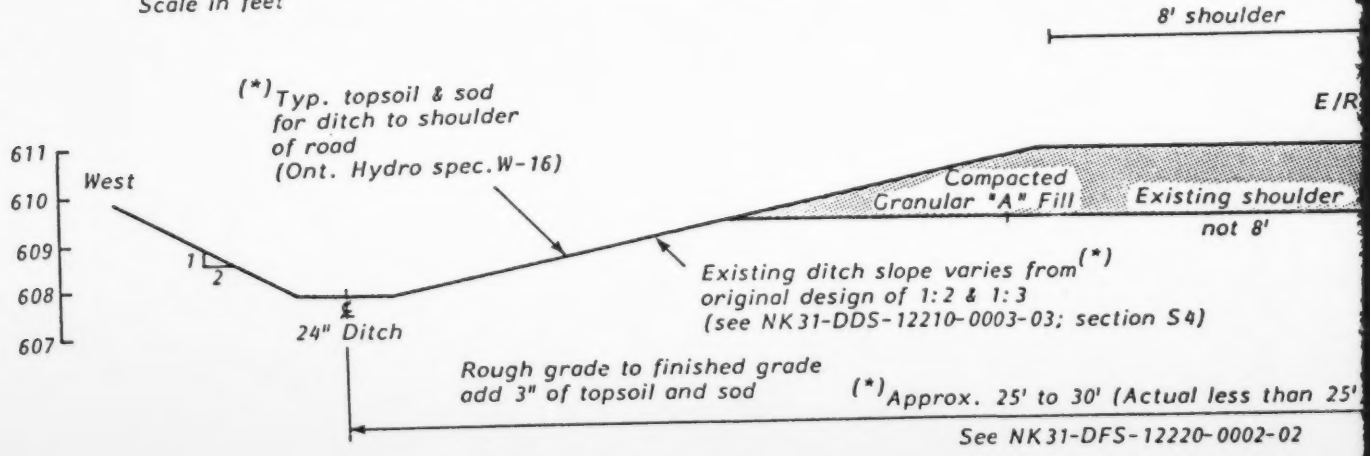


FIGURE 2

CROSS-SECTION OF NEW RO

@ (2)

respect to ℄ of
control points and

xisting site due to
ons (2) to (8)
on results of a

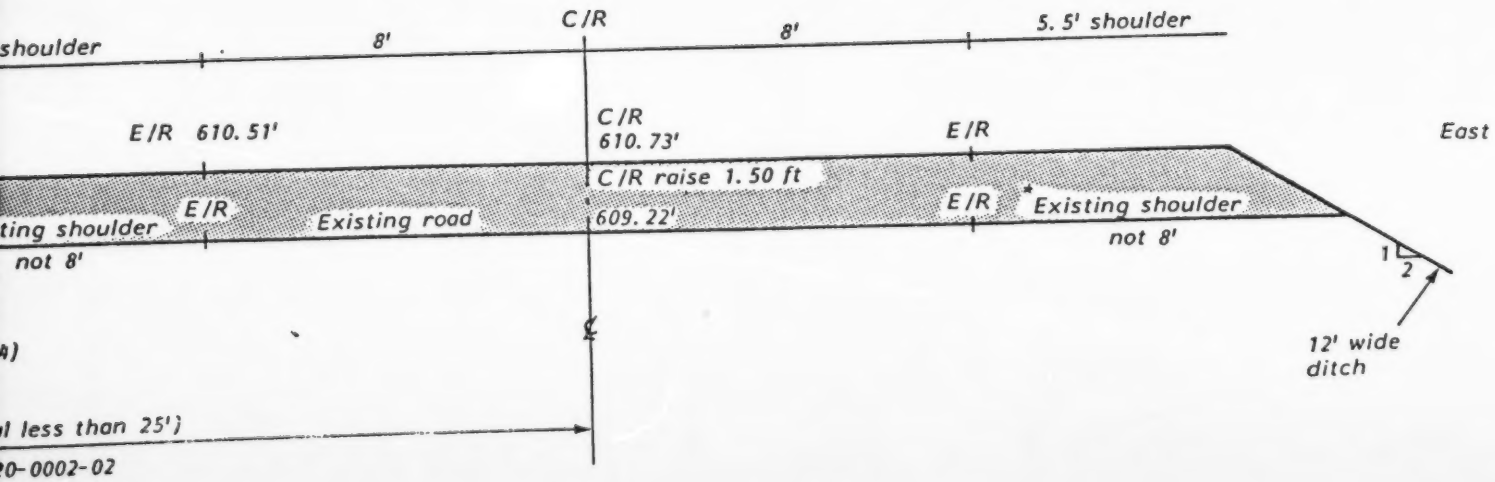


FIGURE 2
OF NEW ROAD AND EXISTING

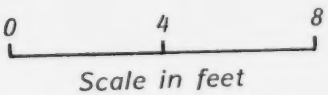
86-188

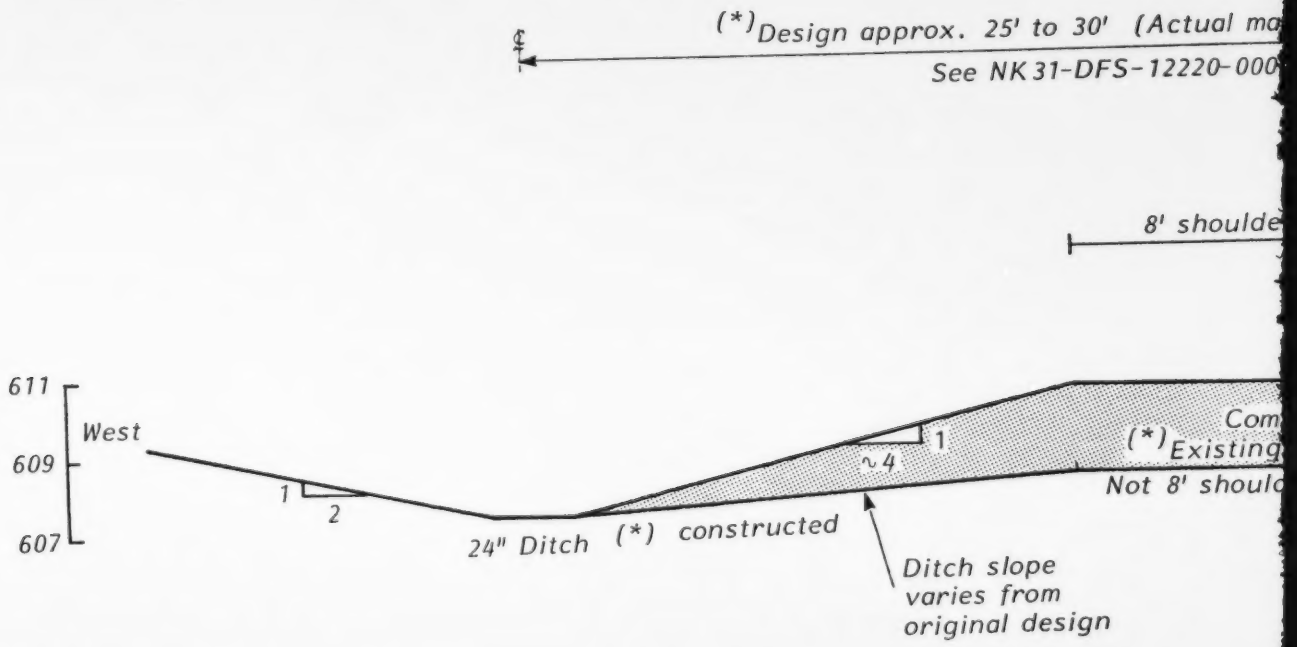
200560 RD

Detailed section at ④ (200' N of gate entrance)

NOTE: (*) 1) Refer to Fig. 1 and 2 for further details

C/R Crown of road finished elevation (ft)
E/R Edge of road finished elevation (ft)





CROSS-SECTION

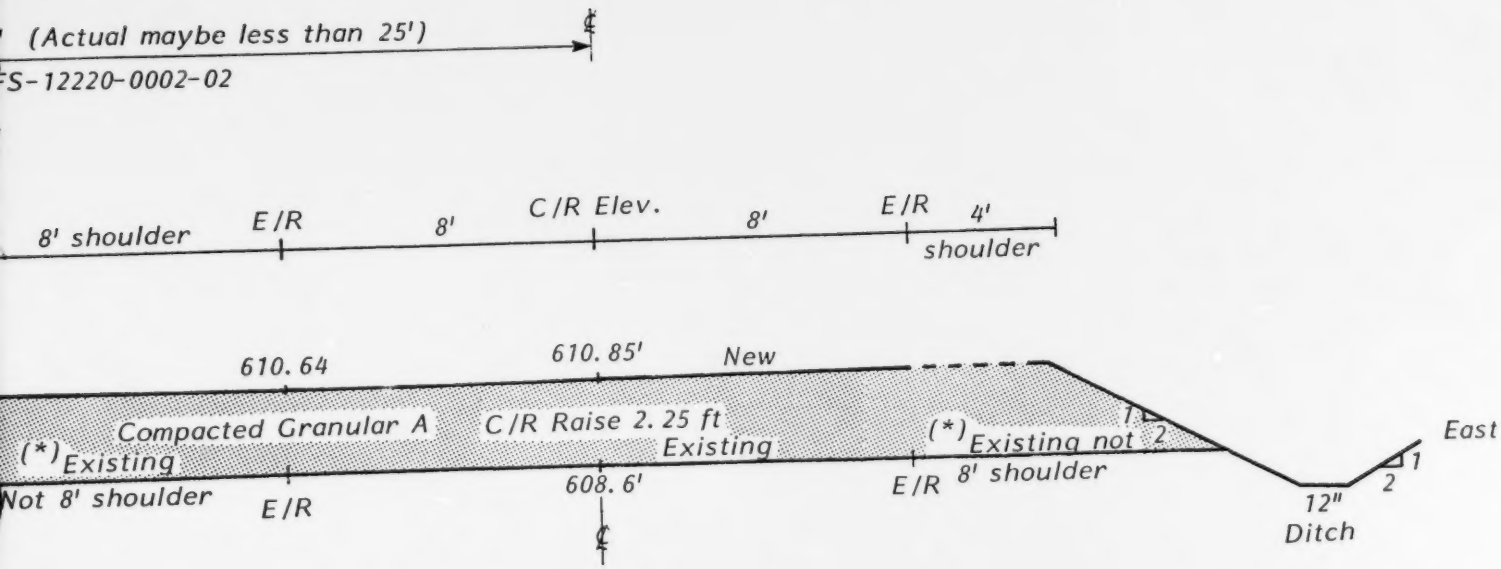


FIGURE 3

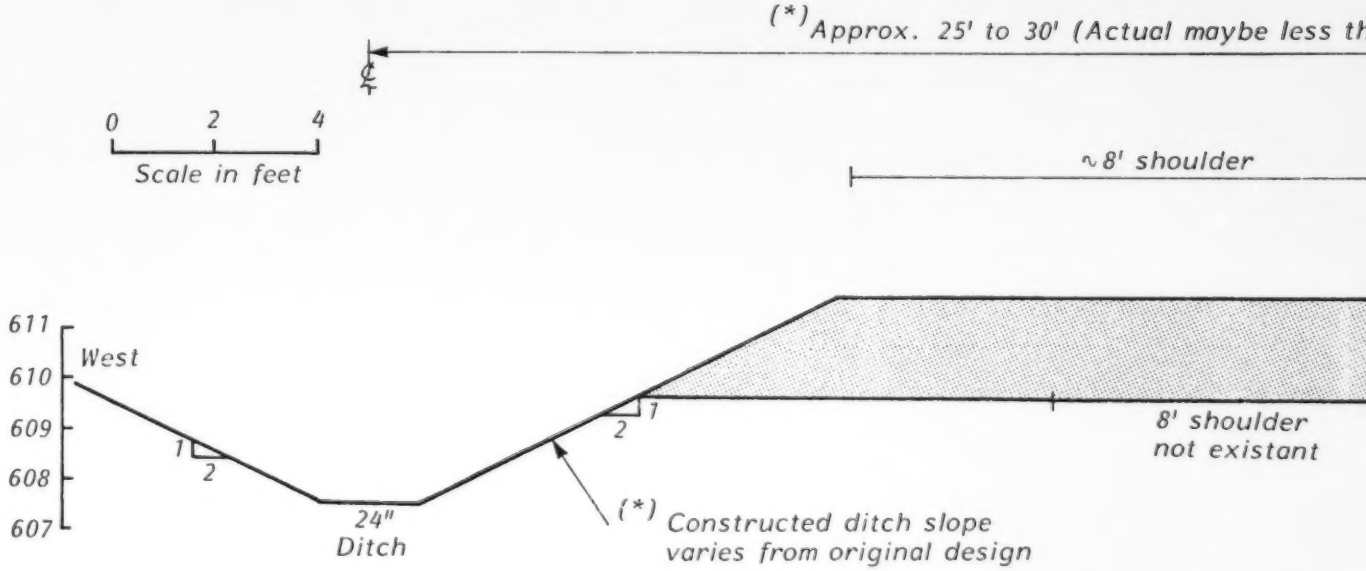
S-SECTION OF NEW ROAD AND EXISTING

Detailed section at (5) (150' N of gate entrance)

NOTE: (*)1) Refer to Fig. 1 & 2 for further details

C/R Crown of road finished elevation (ft)

E/R Edge of road finished elevation (ft)



CROSS-SEC

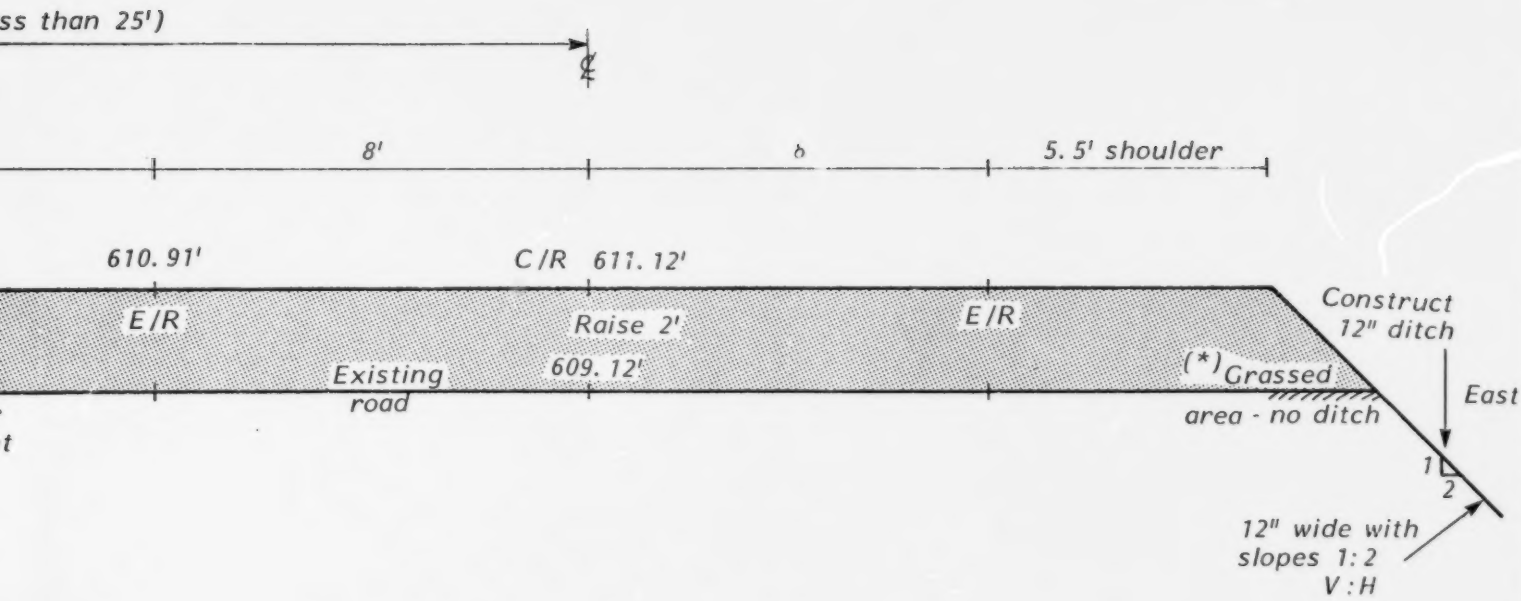


FIGURE 4

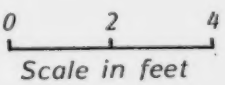
-SECTION OF NEW ROAD AND EXISTING

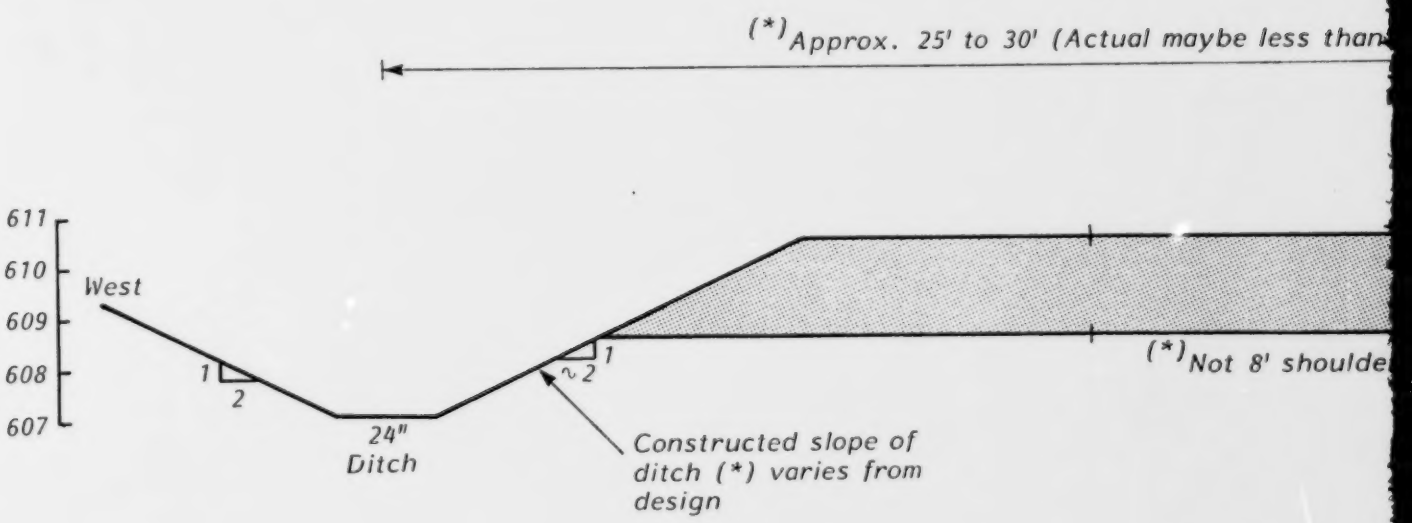
Detailed section at (6) (100' N of gate entrance)

*NOTE: * (1) Refer to Fig. 1 & 2 for further details*

C/R Crown of road finished elevation (ft)

E/R Edge of road finished elevation (ft)





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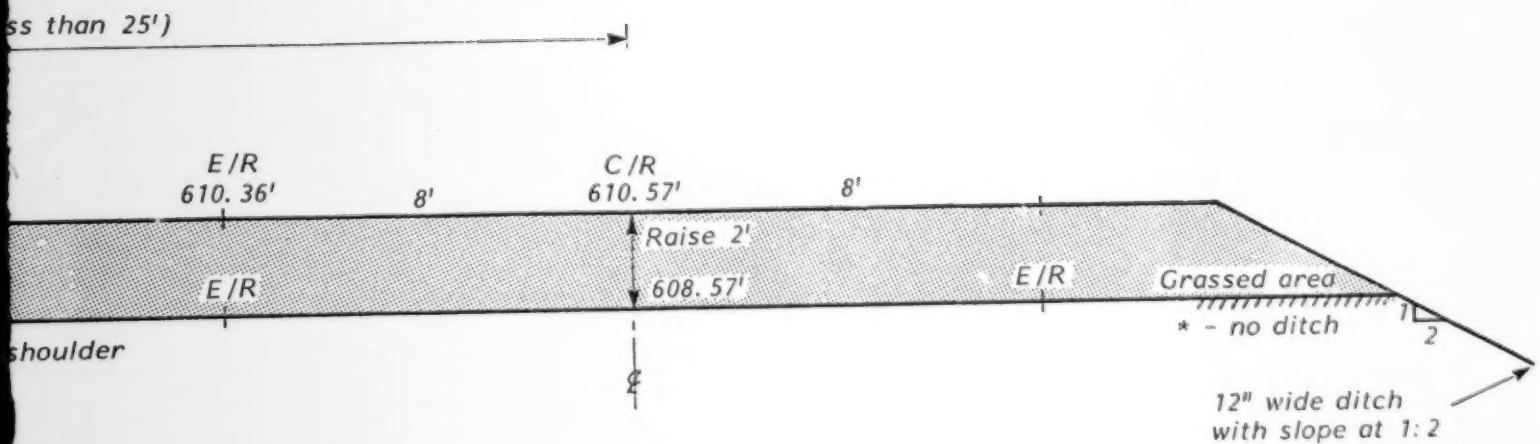


FIGURE 5

-SECTION OF NEW ROAD AND EXISTING

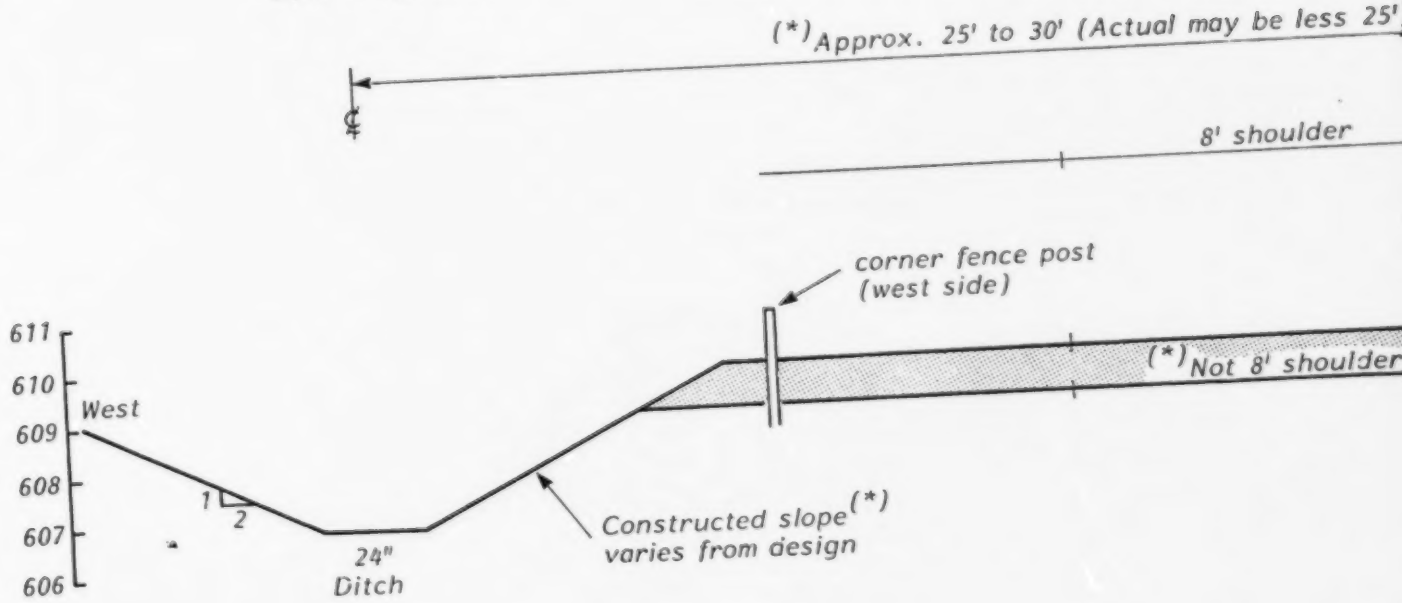
Detailed section at (7) (Gate entrance 0.00' N)

NOTE: 1) From Section (7) taper road level to elev. ~609' (100' S of entrance ga

*2) Refer to Fig 1. & 2 for further details

C/R Crown of road finished elevation (ft)

E/R Edge of road finished elevation (ft)



CROSS-SECTION O

nce gate) at section (8)

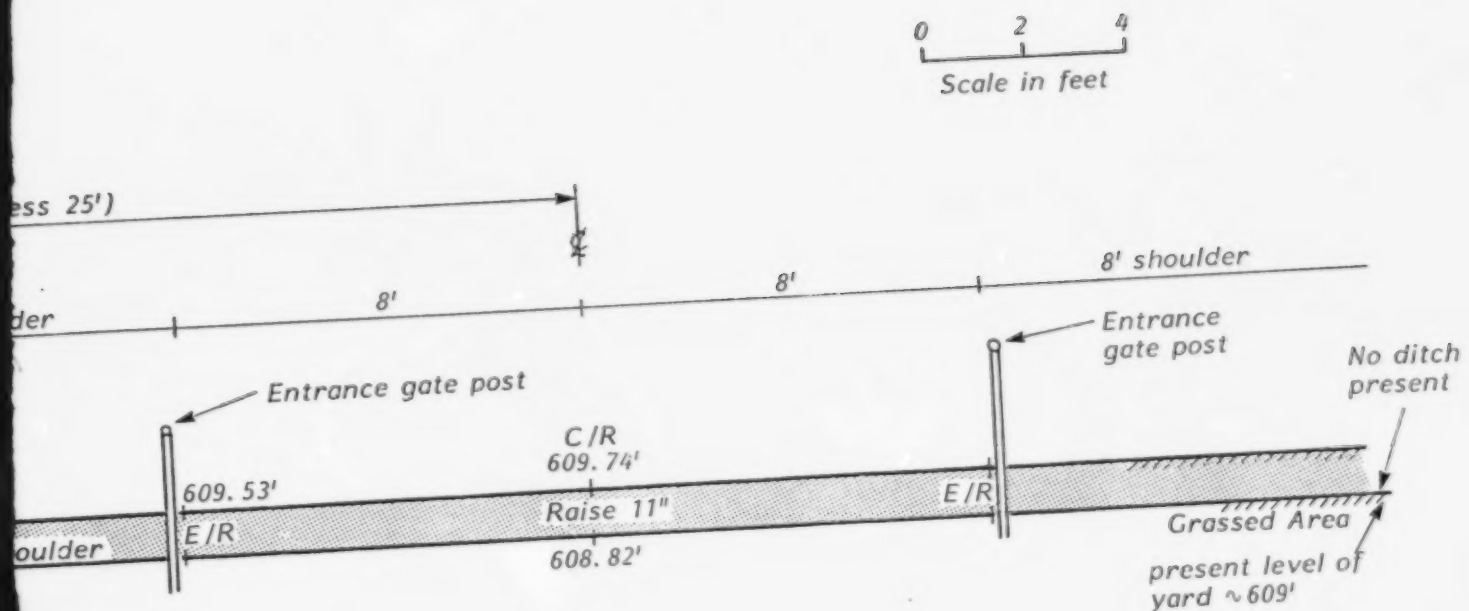


FIGURE 6
ON OF NEW ROAD AND EXISTING

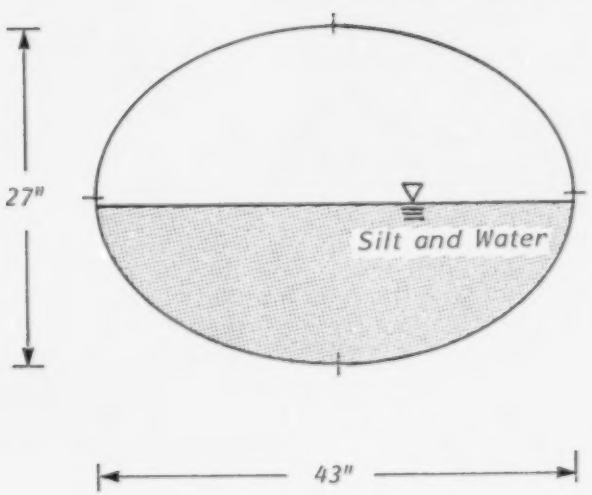
86-188

200564 RD

Section S1 - S1

43" x 27" Pipe Arch

@ estimated length 37.5' [from S2 - S2]
@ top of pipe designed 602'-9" ± [from S2 - S2]
(NK31-DFS-12410-0001-03)



Recommendations:

1) Flush out culvert from ma
(* Estimated silt infill to
arch outlet)

2) Clean out ditch of silt and
and regrade ditch to 0.5%
Off-Site of T.S., Fig. 1-2)

square

In

(~ 98 ft back projection)

* Assuming no change in

FIGUR

CROSS-SECTION OF SILT-FILLED CUL

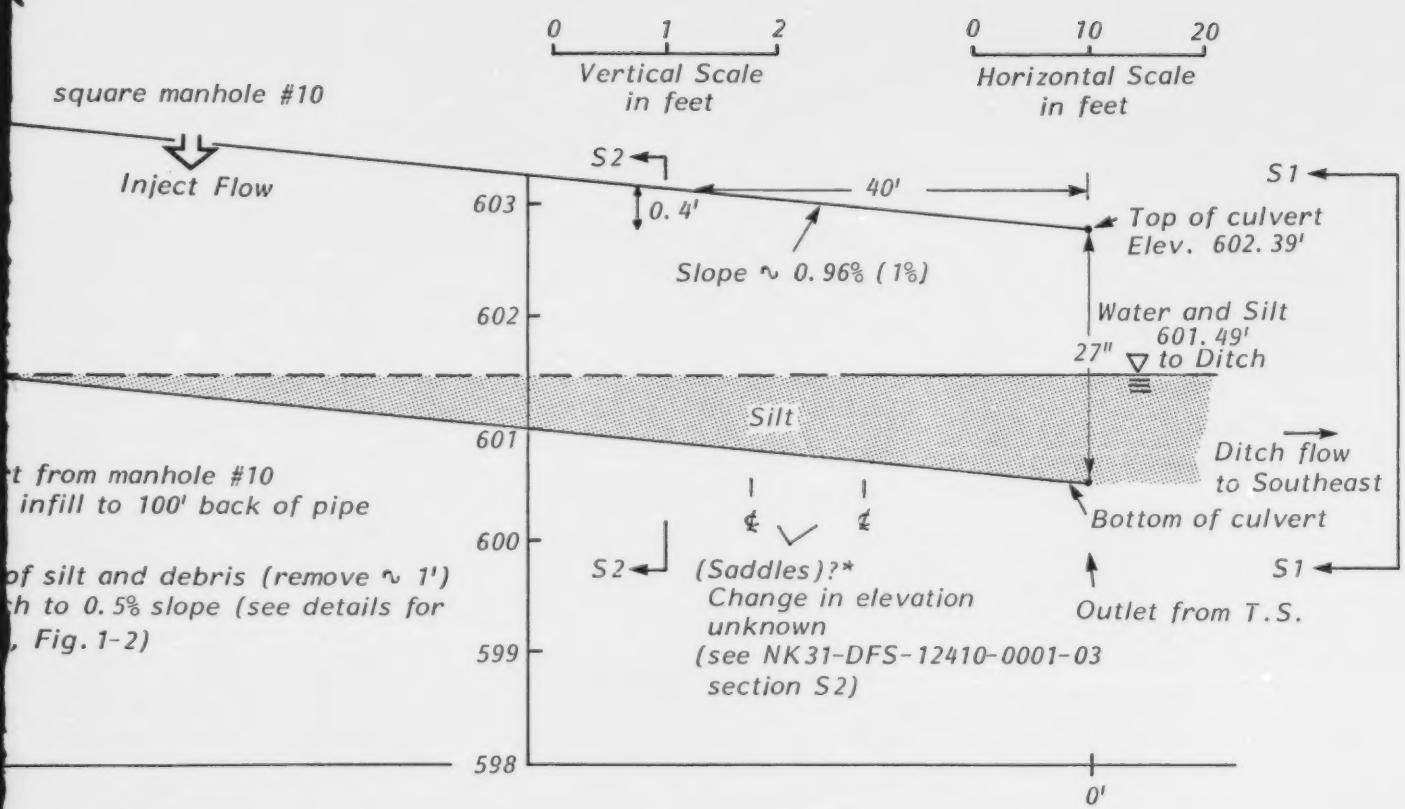


FIGURE 7

LLED CULVERT AT SE CORNER (*EXISTING*)

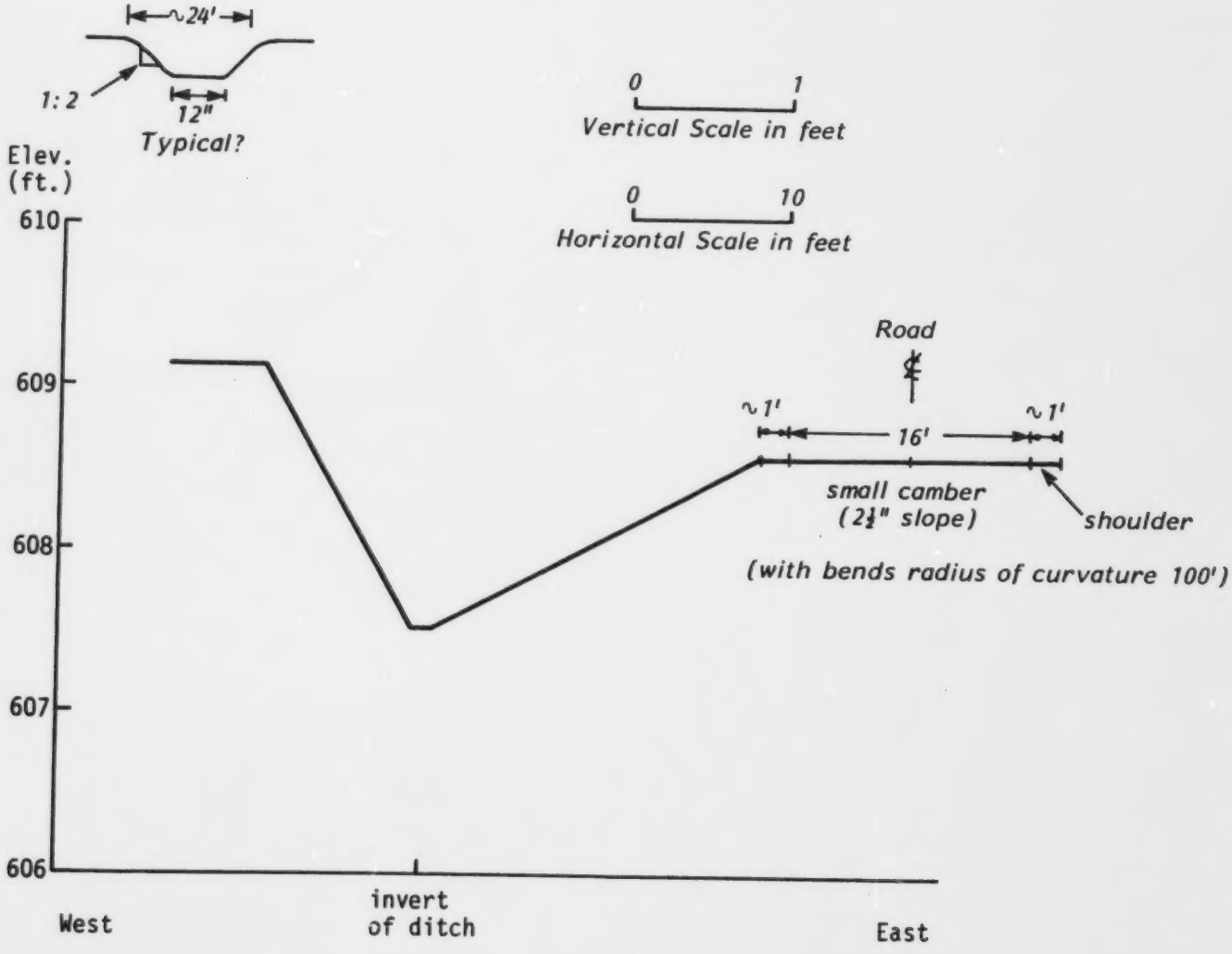


FIGURE 8

EXISTING CROSS-SECTION OF DITCH AT SURVEY LOCATION ④
200' N OF FENCE ON WEST SIDE OF N ACCESS ROAD

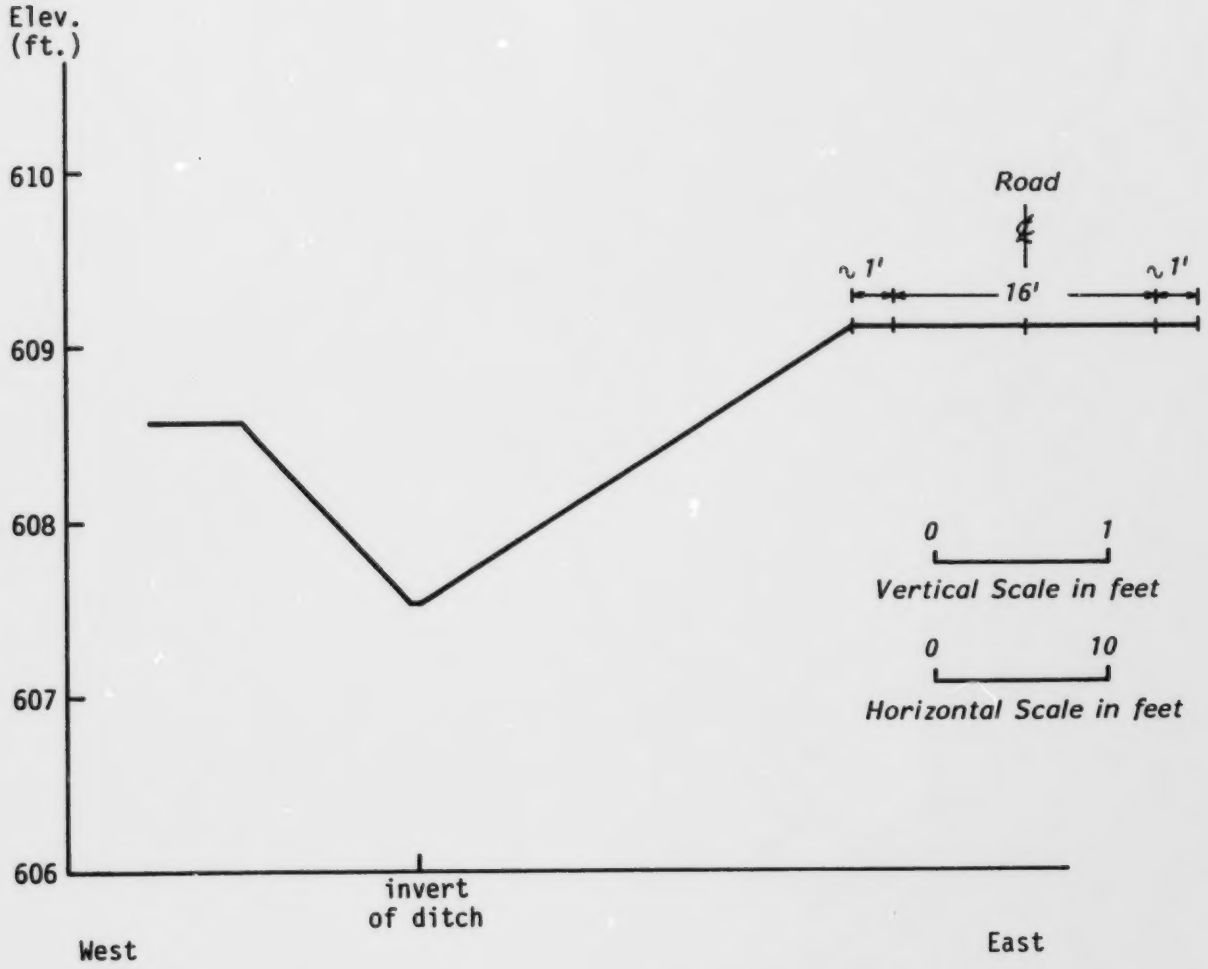


FIGURE 9

EXISTING CROSS-SECTION OF DITCH AT SURVEY LOCATION ⑤
150' N OF FENCE ON WEST SIDE OF N ACCESS ROAD

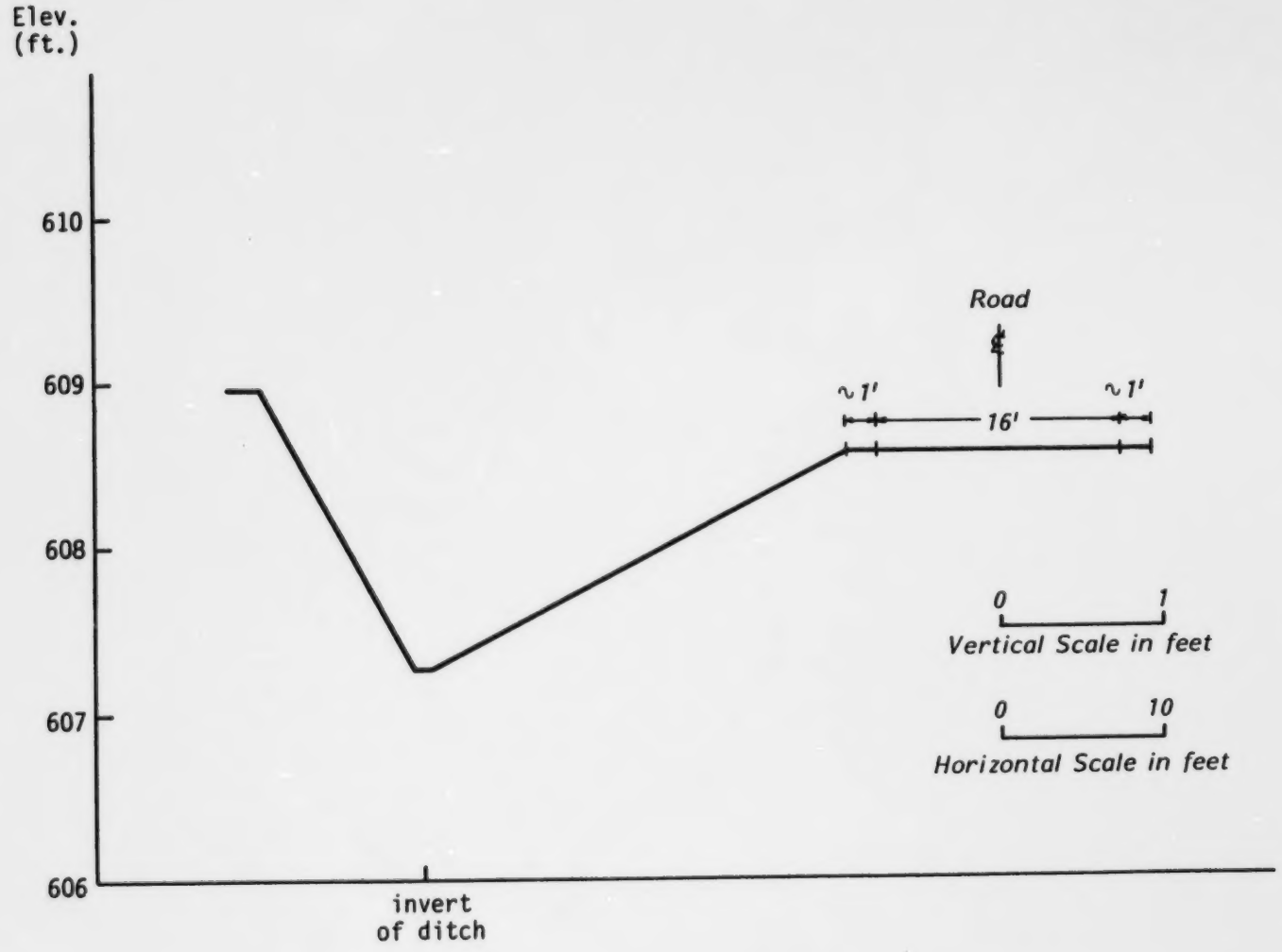


FIGURE 10

EXISTING CROSS-SECTION OF DITCH AT SURVEY LOCATION ⑥
100' N OF FENCE ON WEST SIDE OF N ACCESS ROAD

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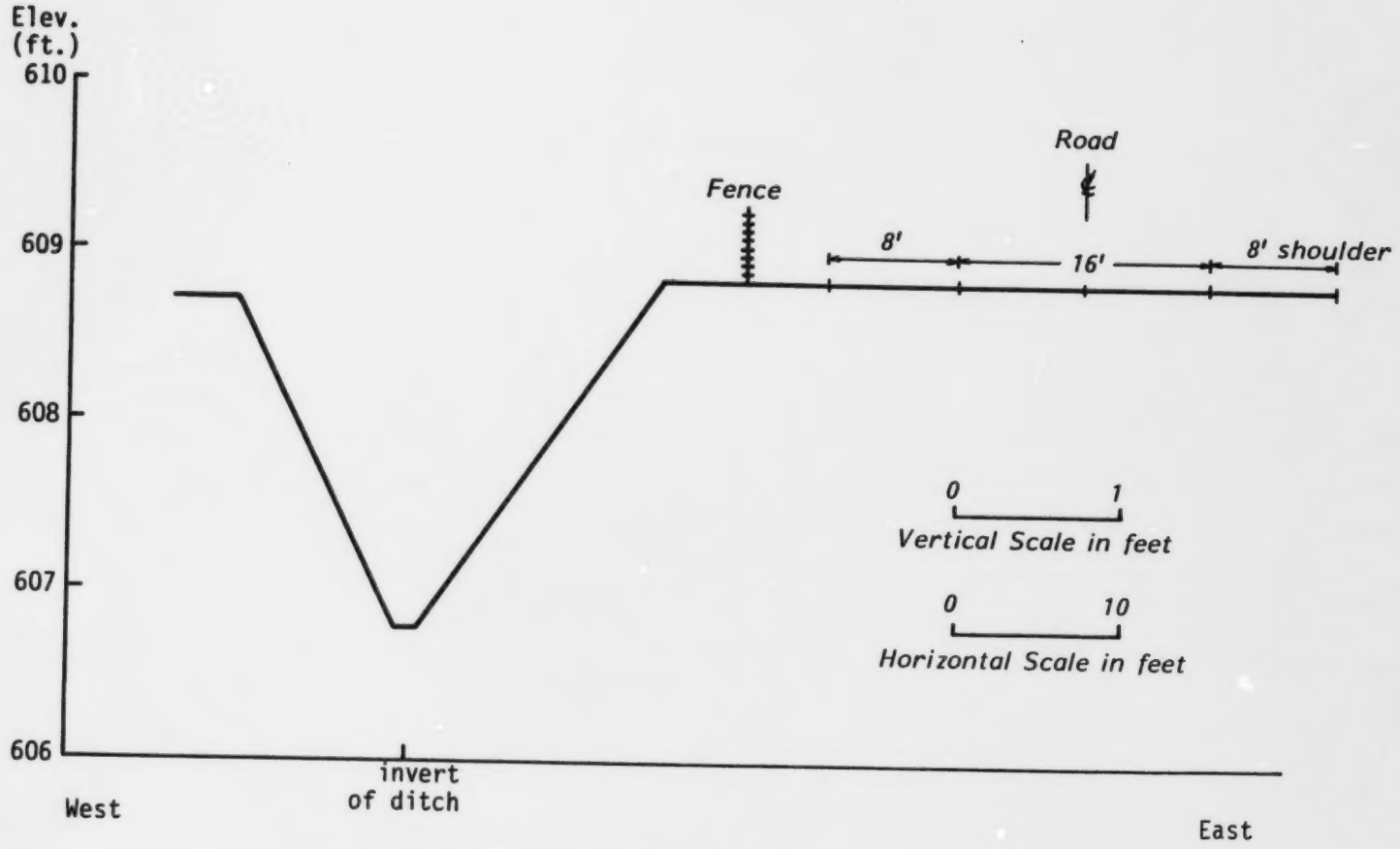

FIGURE 11

EXISTING CROSS-SECTION OF DITCH AT SURVEY LOCATION (7)
ON N FENCE ON WEST SIDE OF N ACCESS ROAD

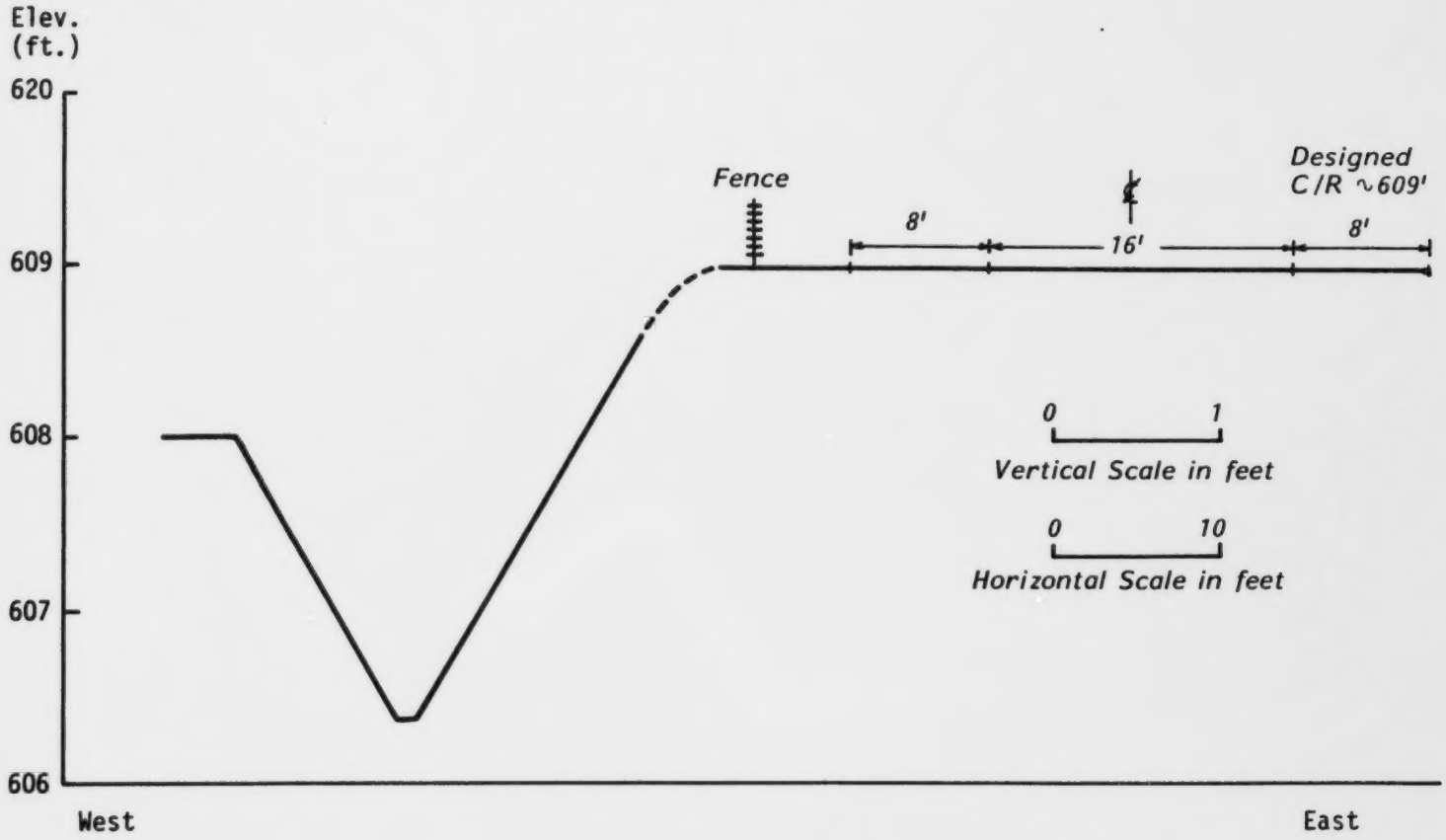

FIGURE 12

EXISTING CROSS-SECTION OF DITCH AT SURVEY LOCATION (8)
100' S OF FENCE ON WEST SIDE OF N ACCESS ROAD

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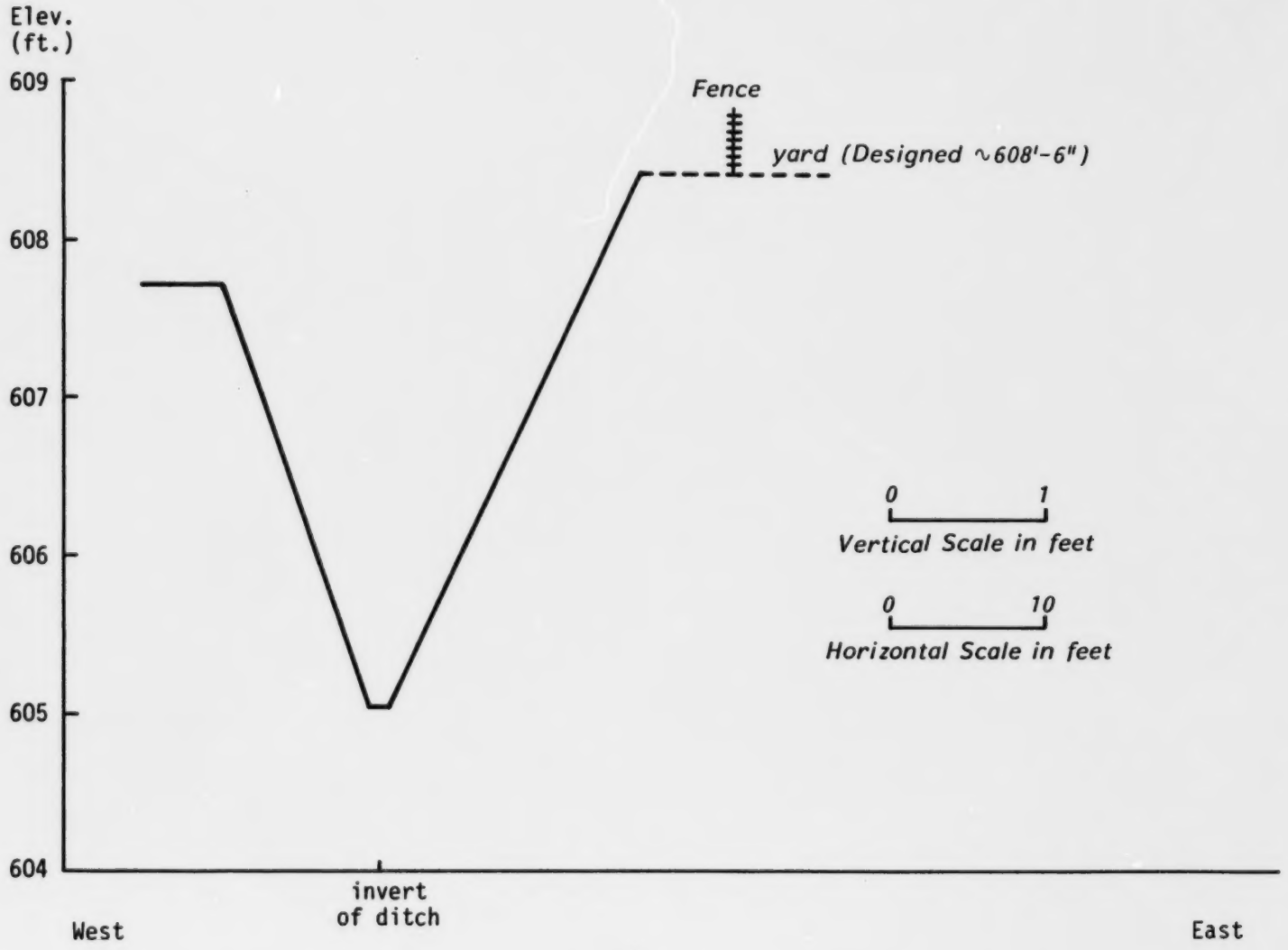

FIGURE 13

TYPICAL CROSS-SECTION OF N-S DITCH ON WEST SIDE OF SITE
AT SURVEY LOCATION (12) ~425' S OF FENCE

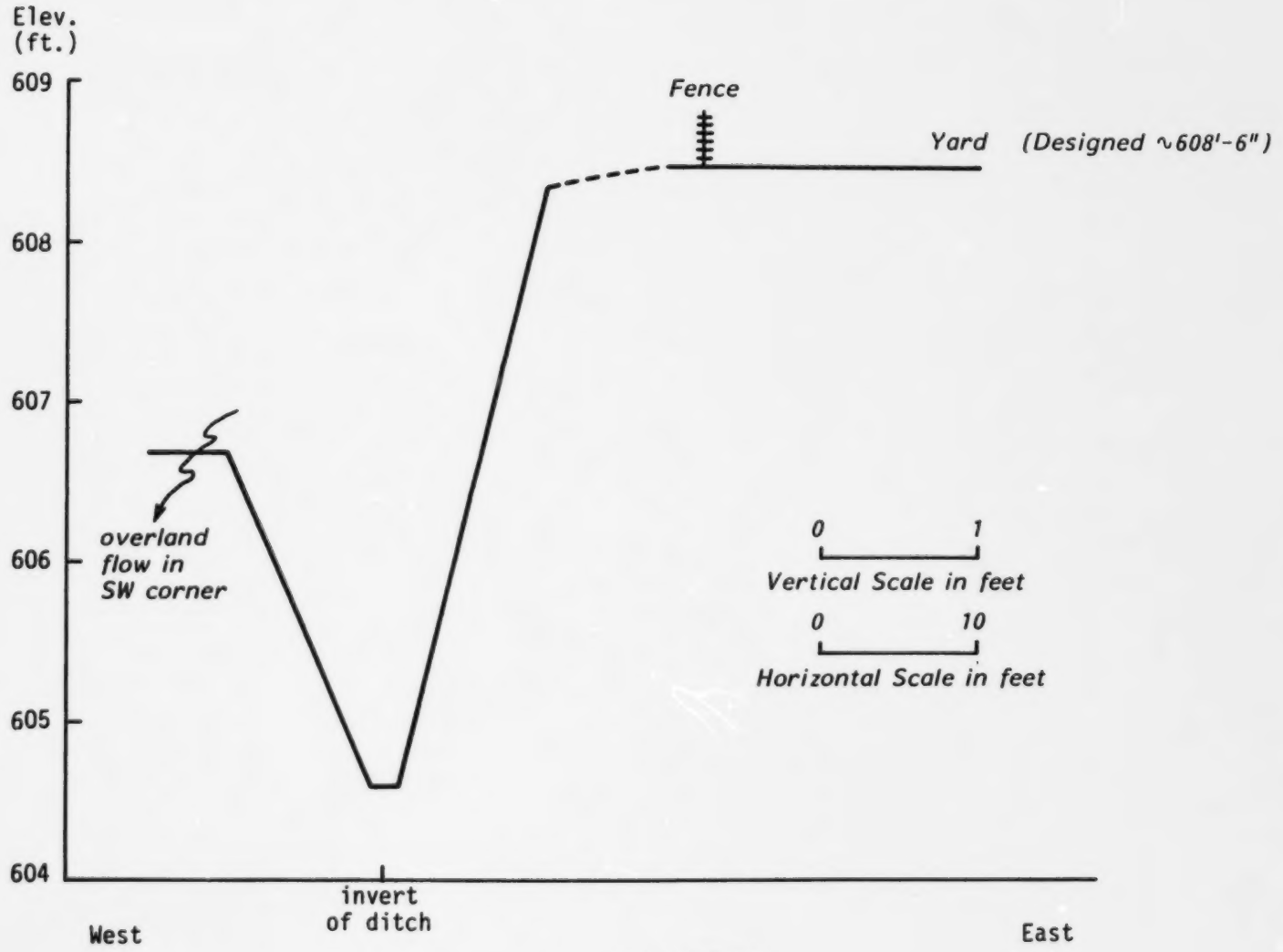

FIGURE 14

EXISTING CROSS-SECTION OF DITCH AT SURVEY LOCATION (13) ~525' S OF FENCE ON WEST SIDE

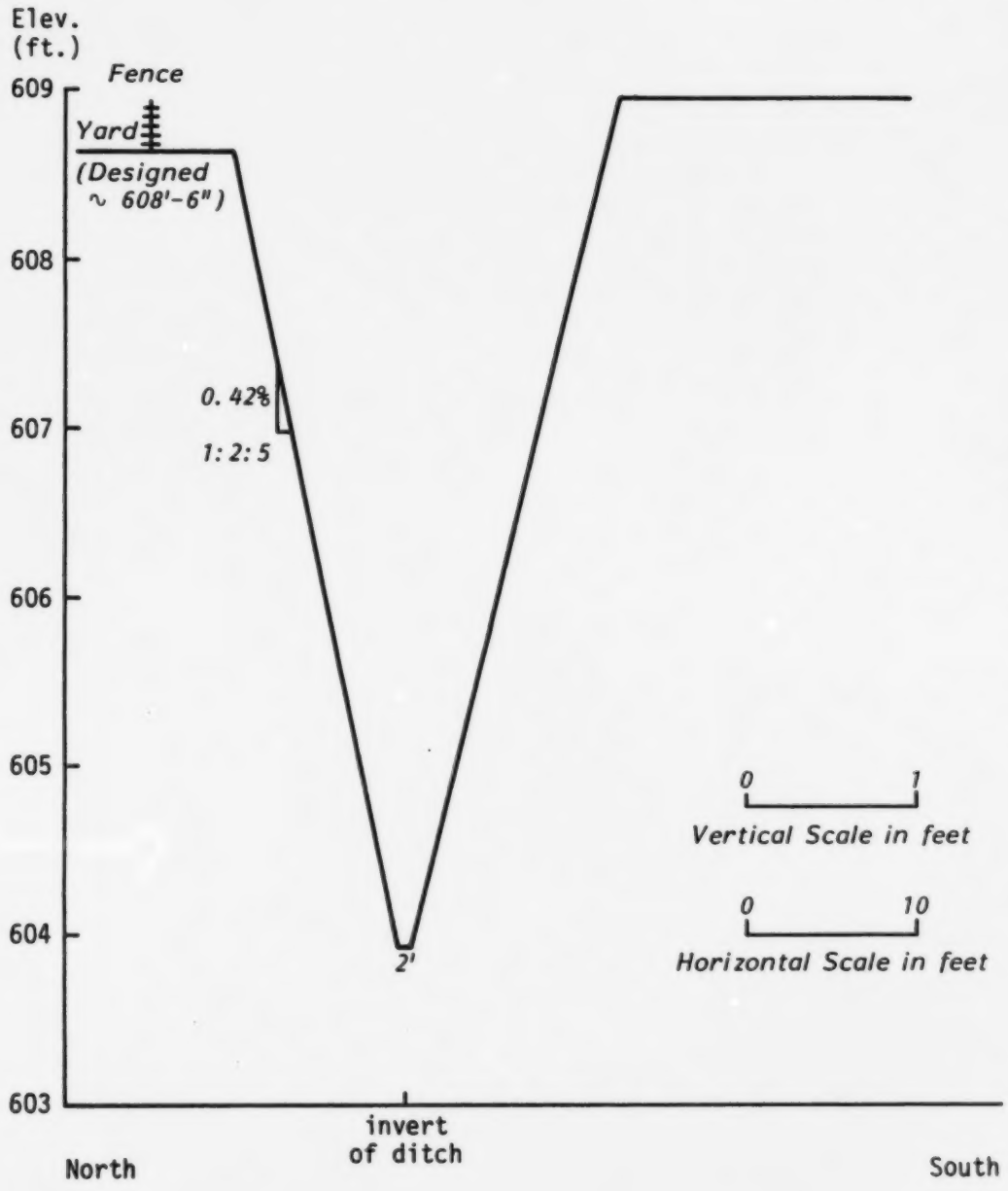

FIGURE 15

TYPICAL CROSS-SECTION OF DITCH AT SURVEY LOCATION (16)
~ 565' S OF FENCE FLOWING E/W ON SOUTH SIDE OF YARD

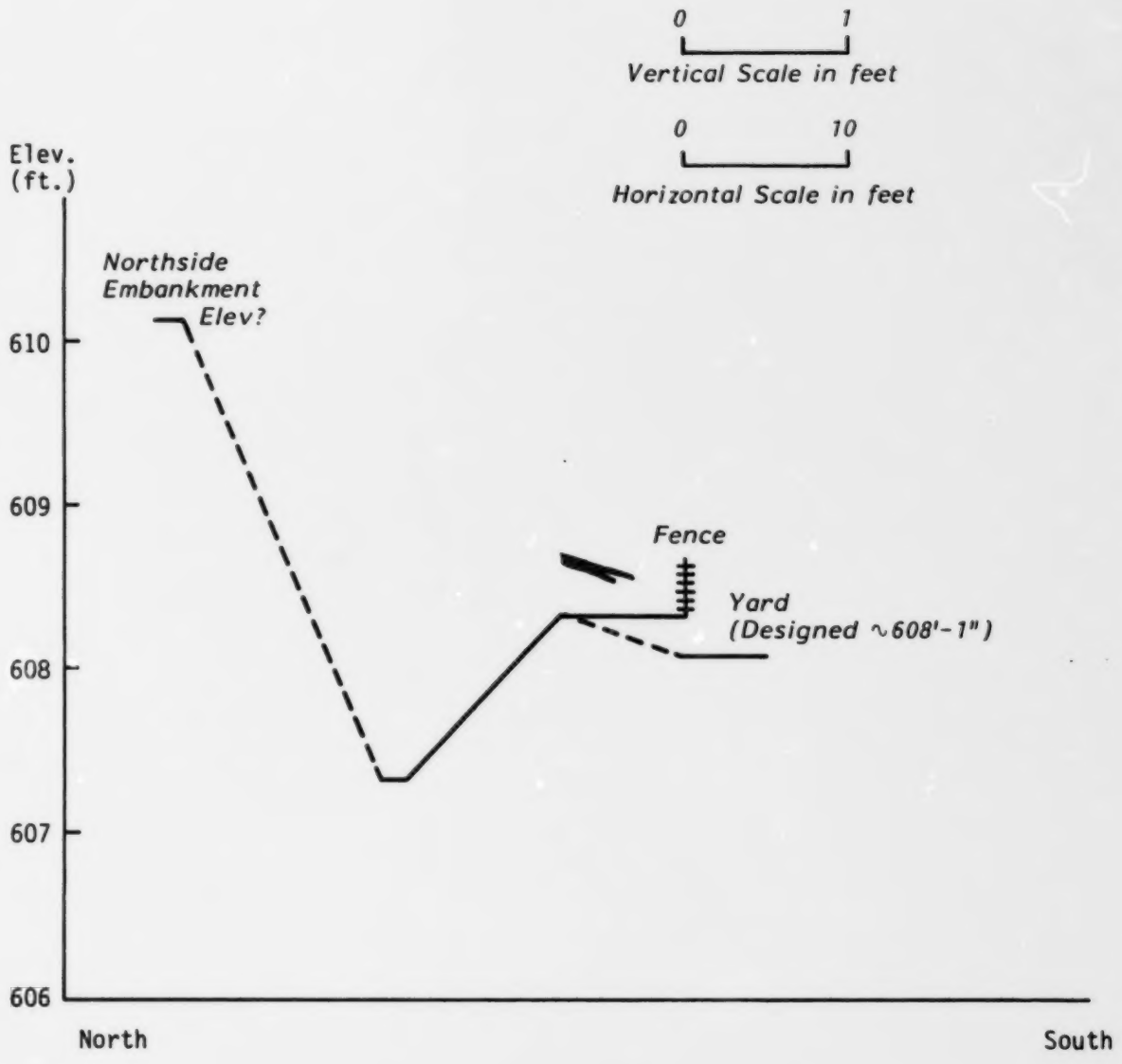

FIGURE 16

TYPICAL CROSS-SECTION OF DITCH (FOR SURVEY LOCATIONS (32) TO (36)) 150' N OF FENCE FLOWING E/W ON NORTH SIDE OF SITE